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Ship Design

Three articles in this issue deal with important problems relating to ship design. The first explains a method of determining the principal dimensions of merchant steamers, and is based upon the method outlined many years ago by Naval Constructor Woodward for the design of a naval vessel. The second is from a paper read before the International Engineering Congress by Rear Admiral D. W. Taylor, chief constructor of the United States Navy. This paper describes the application of mathematical formulæ to the determination of ships' lines, and shows the important part played by model tank experiments in the solution of problems relating to resistance, propulsion and rolling of ships. The third article takes up, from a thoroughly practical standpoint, the design of small screw propellers, a question that has become of vital importance since the general adoption of direct turbine drive in high-speed ships. In the solution of most problems of hull and propeller design the naval architect is greatly indebted to the work carried out at model experiment tanks, and shipowners are beginning to realize the economic value of expenditures made for experimental work of this kind. The mass of useful data from such investigations is daily increasing, but, unfortunately, much of it is inaccessible for general use.

The Spoils of War

Two lists have been sent to our office showing the total number and aggregate tonnage of both merchant and war vessels lost during the first year of the European war. The accuracy of these lists cannot be vouched for beyond the fact that they were carefully compiled from reports taken from the *Manilla Bulletin, New York Herald, Berliner Tageblatt, London Shipping Record, North China Daily News, Hamburger Nachrichten* and *Ostasiatischer Lloyd.* A general summary of these figures, however, may be of interest to our readers. The list of merchant ships lost is taken from newspaper reports up to August 6, 1915, and that of warships from reports up to July 27, 1915. The grand total of both merchant and war vessels of all nations either captured or sunk during this period was 880 of 2,161,376 tons. These figures do not include vessels detained, except those of neutral nations. Of the vessels included in the above total, 566 of 1,395,446 tons belonged to the Allies, while 211 of 574,361 tons belonged to Germany, Austria or Turkey. The remaining ships, 103 of 191,567 tons, belonged to neutral nations. The general summary further states that the total number of merchant ships lost was 756 of 1,692,773 tons, of which 497 of 1,054,387 tons belonged to the Allies, as against 156 of 446,817 tons belonging to Germany and her allies. The warships lost by Great Britain, France, Russia, Italy, Japan and Belgium numbered 69 of 341,059 tons, while the warships lost by Germany, Austria and Turkey totaled 55 of 127,544 tons. At the outbreak of war 79 British steamers of 172,988 tons were detained in German ports, 102 German vessels of 200,000 tons were detained in British ports and 57 Austrian and German vessels were detained in Italian ports.

Marine Terminals

It is not surprising to learn that at many of the marine terminals in the United States it often happens that the cost of loading and discharging vessels is greater than the actual cost of transporting freight on board ship between ports. This holds true more frequently in cases where the cargoes consist of miscellaneous package freight, and is due chiefly to the fact that little progress has been made in equipping American marine terminals with up-to-date machinery for the rapid and economical handling of this class of freight. Old and antiquated methods have been tenaciously adhered to in spite of the enormous increase in the volume of freight shipped from our ports and the result has been congestion and excessive costs.

The problem of reducing the high cost of the present methods of handling miscellaneous cargoes and of reducing the time required for loading and discharging vessels was discussed at length by Mr. H. McL. Harding, formerly consulting engineer of the Department of Docks and Ferries of the city of New York, in a paper read last month before the International Engineering Congress at San Francisco. The elements of a complete marine terminal, as described in this paper, consist of piers, slips, quays, railroad tracks and yards, sheds, warehouses, dray areas, open storage spaces and often public markets, cold storage buildings, coal pockets and manufacturing lofts, as well as sheds and warehouses for special commodities. For the economical handling of miscellaneous freight at such a terminal Mr. Harding advocates the installation of me-

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chanical appliances for hoisting and conveying the freight so that it can be transferred in the most direct way and with the least possible rehandling to any part of the terminal plant. It is pointed out, however, that the success of such a terminal depends not only upon the layout and equipment of the terminal itself, but also upon the design of the vessels and of their freight-handling machinery, and here the naval architect must be depended upon to cooperate with the terminal engineer.

Mr. Harding's recommendations call for at least two double winches for each hatchway on the ship and sufficient booms for burtoning the loads simultaneously either upon the shore or upon lighters. On the quay or piers the installation of traveling gantry jib cranes is recommended, one for each 100 feet of lineal frontage, spanning two or three railway tracks, which should be located between the shed and the quay wall. Within the shed overhead movable cross tracks are advocated, connecting with fixed side tracks, so as to assort and distribute the freight by a continuous succession of movements without rehandling and without using floor space, thus making available every cubic foot of space in the shed for the disposal of freight. This arrangement would afford a short path across the shed from a vessel on one side of the pier to another vessel on the other side, and the freight would be moved without congestion or delay by burtoning between the hooks of the gantry cranes, or ship's winches, and the hooks of the traveling hoists.

The above system may be said to apply in general to any marine terminal, although modifications and adaptations may be necessary in individual designs, depending upon the natural physical conditions of the terminal and the nature of the service for which it is intended.

Naval Preparedness

If the United States had had a large and efficient navy in 1897 there would have been no Spanish war, and if we had a large and efficient navy to-day there would be no ignoring of the rights of ordinary citizens to travel on the ocean, nor would there be the evident contempt for any expression of opinion on the part of our Government from certain belligerent sources. The attention of Congress has been called to this situation over and over again, but without avail. Naval bill after naval bill has aroused great opposition, resulting in compromises and, as a consequence, our naval strength has dropped from a commanding second position until it is now fourth or fifth among nations.

We need ships and we need trained men. Politicians and men high in office seem to think that talk will produce both of these, judging by the editorial comments and interviews appearing almost daily in the newspapers. Meanwhile, nothing is done. The Secretary of the Navy urges a naval reserve composed of men who have had naval training, but who have left the navy and returned to civil life. Such a reserve is a cheap imitation of the reserve that we need, for there can be no real preparedness simply by using only retired naval men.

What we need and must have, if preparedness is to be anything but talk, is a complete complement of men—masters, watch officers and seamen—who have had years of experience and who can be depended upon to navigate any vessels to which they are assigned. The great efficiency of the English navy when the present great war broke out was helped materially by the very capable naval reserves drawn from the merchant marine. These men must be trained along naval lines and, what is more important, they must be paid in order to secure their services in case of necessity.

No measure has ever been proposed that will aid naval preparedness and, at the same time, help build up the merchant marine in the foreign trade as well as the one referred to on page 145 of our issue of April last. The plan that we proposed was part of a bill to build up the American merchant marine in the foreign trade and, at the same time, to provide a special naval reserve that could be called upon instantly and that must of necessity be an efficient reserve, as all of the men would be in actual service on board merchant ships.

The first part of the bill is vital to the upbuilding of the merchant marine, in that the Government is the only source of financial support that can be looked to in these times for money to invest in ships. If the Government takes bonds in steamship companies up to a certain percentage of the value of the vessels, the security is of the very best. If interest in the merchant marine could be established by the Government encouraging the building and operating of ships in the foreign trade, the whole country would benefit, but the navy would benefit far more by the thorough training of a special naval reserve consisting of men who are doing duty every day on these merchant vessels.

A feature of the bill establishing this reserve requires that the men be citizens of the United States in order to benefit by the extra pay, and this benefit is extended not only to the masters, but watch officers and seamen. They are paid the difference in wages of the American rate and the rate paid on the competing ships flying other than American flags. Under this measure their wages are automatically maintained at the level of the American wage scale, and the men are all under obligation to serve the navy in case of need. It is estimated that $2,000,000 (£410,000) invested in this manner would support 32 merchant ships of 5,000 tons each for a year in the foreign trade. We would, at the same time, be building up our merchant marine for foreign trade on a substantial basis and be putting the navy into that condition for preparedness which it ought to be.

If Congress would take action along these lines and politicians and men high in office support such action, the question of naval preparedness would soon be effectively and efficiently solved. A splendid corps of men that would be invaluable in case of emergency could be trained in

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this way for service in the navy, and the cost of this training would be scarcely half what it would cost to have the men trained on war vessels. Furthermore, the merchant marine in the foreign trade would be rapidly built up, so that the American flag in a very short period of time would be seen in all the great ports of the world.

The Task of Developing the American Merchant Marine

In a communication recently sent to the marine press, Mr. A. C. Holzapfel, who has long been identified with industries allied with shipbuilding and shipowning, analyzes the conditions which in his opinion are preventing the development of the American merchant marine in the foreign trade. He says, in part:

"That this country badly needs a mercantile marine for an international carrying trade, that it has the money to acquire such a marine, and that such a marine will have to be acquired during the next few years no sensible man can dispute. The two chief impedimenta which prevented American shipowners from developing international carrying trade in American bottoms were, until recent years, first, the impossibility of acquiring foreign-built ships and giving them the American flag, and second, the high import duties on steel (abolished several years ago) which enabled American steel manufacturers to charge higher prices for shipbuilding material than those ruling in foreign countries. Both of these disabilities have been removed and American steel is now sold in this country at prices 25 to 30 percent less than in Europe.

"There still remain, however, three difficulties which will have to be overcome before a general and unrestrained development of the building and owning of ocean steamers in this country can be accomplished. These are the following:

"First, financial shipping investments are in evil repute among American financiers owing to the gross over-capitalization of the International Mercantile Marine Company, which, however, is now being remedied by a drastic capital reorganization; also owing to the questionable financial system pursued by Mr. Morse when he combined the coasting fleets of this country.

"The second drawback is due to the insufficient insurance facilities for ships sailing under the American flag. The Government has already taken some steps to meet in some measure this difficulty which have resulted in considerable profit to the Government. Whether a government which wants to develop the shipping industry is wise in extracting large profits from such an industry during its development is obviously open to serious doubt. So far as I can ascertain, various comparatively small organizations dealing with ship insurance have done so to considerable profit; still, we are entirely without such an institution as Lloyds Underwriters of London, who transact probably 80 percent of the total sea insurance business of the world. It is surprising that this system of private underwriting has not been adopted to a substantial extent in the United States. Its adoption and the resultant facilities and economies for marine insurance would, no doubt, largely contribute to the development of an American merchant marine.

"The third disability is the fact that shipbuilding in the United States, in spite of the lower prices of steel, is still much more expensive than in Europe. The reason for this is the undoubted fact that shipbuilding is not so well organized in this country as in Europe, and that the overhead charges are enormous owing to the lack of specialization. The same builder who builds a battleship will also build a tug boat or a cargo tramp. There is no doubt that with the higher scale of wages obtaining in this country, specialization in shipbuilding is the only means of success. To a large extent shipbuilders on the lakes have specialized in certain types of vessels with very gratifying results. If the same thought and enterprise had been applied to the shipbuilding of the Atlantic coast, better results would have been obtained.

"It need hardly be discussed whether and to what extent Government help will be needed in the impending developments. There can be no doubt, however, that financial support from the public exchequer for a strictly limited period would help beginners over initial difficulties and would also help to attract capital to the shipbuilding and shipowning industries. Above all, let everyone realize that neither shipbuilding nor shipowning should be allowed to be exploited by the financial shark. The history of the two large shipowning combinations to which I have alluded, as well as of the shipbuilding trust founded by Mr. Charles M. Schwab, has proved conclusively that the shipping business cannot exist and compete against the rest of the world except on a strictly sound financial basis."

The premises stated by Mr. Holzapfel do not call for comment. The United States badly needs a merchant marine for its foreign trade, it has the money to develop one, and something will surely be done in that direction in the near future. Not all shipbuilders or shipowners, however, will agree with Mr. Holzapfel's conclusions as to the principal obstacles which are retarding this development.

Mr. Holzapfel ignores entirely the question of the cost of operation of steamships. The cost of building ships in the United States at the present time compares favorably with that in Europe; and as the volume of shipbuilding in this country increases, leading probably to greater specialization and standardization in individual shipyards, this condition will undoubtedly be further improved. The cost of running ships under the American flag, however, is higher than that of competing ships under foreign flags, and will remain so until the laws governing the navigation of American ships are modified or until government aid is extended in some form or other to overcome this barrier. Until this difficulty is overcome, the American merchant marine in over-seas trade will be, as it practically is today, non-existent.

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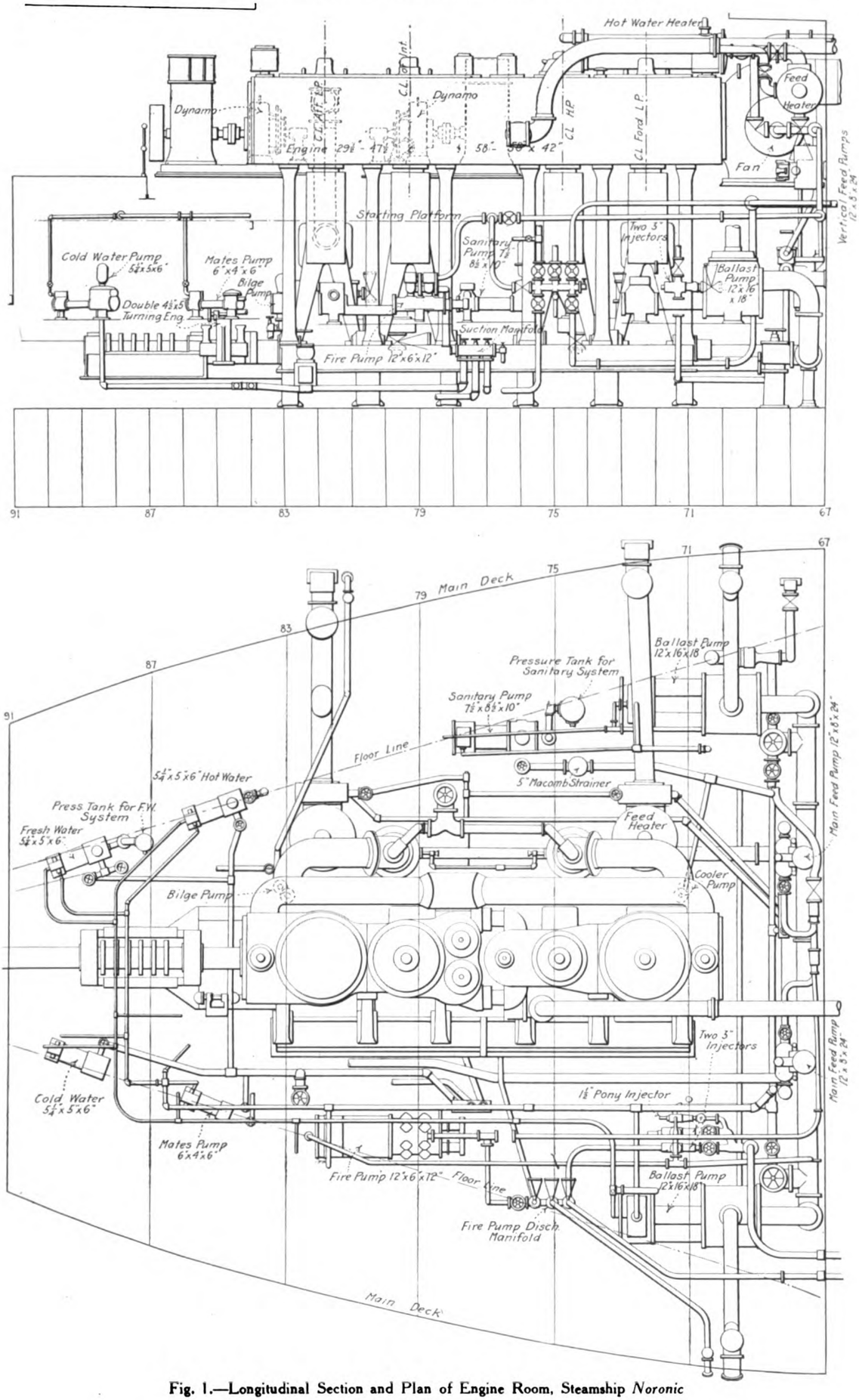

Fig. 1.—Longitudinal Section and Plan of Engine Room, Steamship *Noronic*

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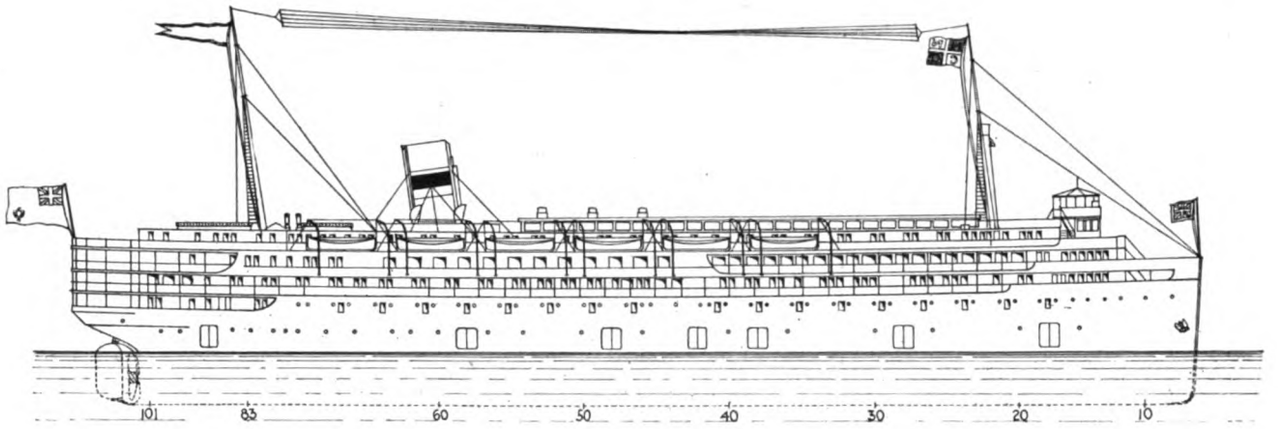

Fig. 2.—Steamship *Noronic*: Length overall, 385 Feet; Beam, 52 Feet; Depth, Molded, 28 Feet 9 Inches

Lake Passenger Steamer Noronic

New Vessel for the Northern Navigation Company, Ltd.—Description of Hull and Machinery—Trial Data

A notable addition was made during the past season to the large fleet of passenger vessels owned and operated by the Northern Navigation Company, Ltd., of Sarnia, Ont., by the completion of the passenger steamer *Noronic*. The hull and boilers were built by the Western Dry Dock & Shipbuilding Company, Ltd., Port Arthur, Ont., and the main engine by the Cleveland plant of the American Shipbuilding Company. The vessel operates on a six-day voyage between Sarnia, Ont., and Duluth, Minn., calling at the Soo and Port Arthur. Her principal dimensions are: Length overall, 385 feet; length between perpendiculars, 362 feet; breadth, molded, 52 feet; depth, molded, 28 feet 9 inches; indicated horsepower, 4,800; contract speed, 16.55 miles per hour,

The hull is built on the Isherwood system of longitudinal construction, a double bottom 4 feet 9 inches deep extending the full length of the ship. The hull is further subdivided by eight watertight bulkheads into nine compartments.

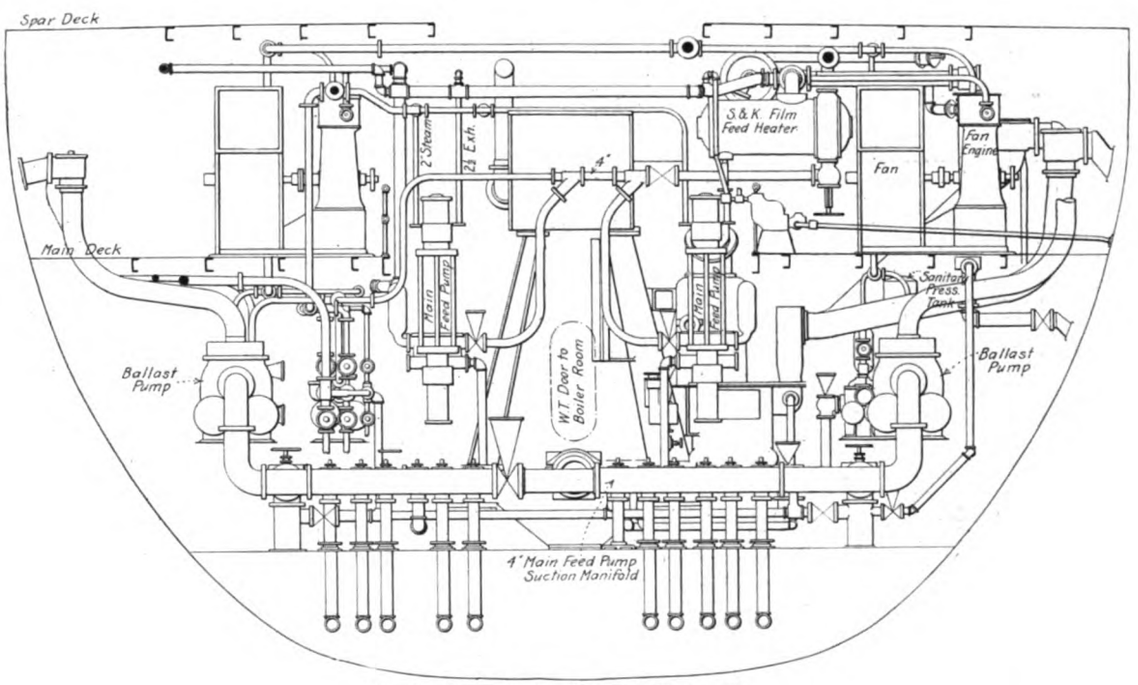

Fig. 3.—Cross Section Through Engine Room

The *Noronic* is noteworthy for the luxurious passenger accommodations provided. There are 279 staterooms and parlors and her main dining room has a seating capacity for 286 persons. In the design of the interior decorations simplicity and goo taste prevail. The entrance hall on the main deck is finished in quartered oak; the spar deck is white enameled except in the social hall or lobby, which is finished in fumed oak. The promenade deck is of mahogany throughout. The dining room, galley, refrigerat-

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ing and observation rooms are located on the observation deck. The observation room is 140 feet long, finished in oak and has a hard wood dancing floor. The dining room is 180 feet long and finished in mahogany. The boat deck is finished in oak and lighted by a large dome skylight. The various cabin decks and houses are all of steel.

The power plant is one of the most complete installations ever placed aboard a lake vessel and embraces every requirement to make up a modern high-class vessel. The engines and boilers are built under Lloyd's rules as well as Canadian Government rules.

PROPELLING MACHINERY

The main engine is a four-cylinder, triple expansion engine balanced on the Yarrow-Schlick-Tweedy system, developing 4,800 indicated horsepower. The cylinder dimensions are 29½, 47½, 58, 58 by 42 inches. In passing

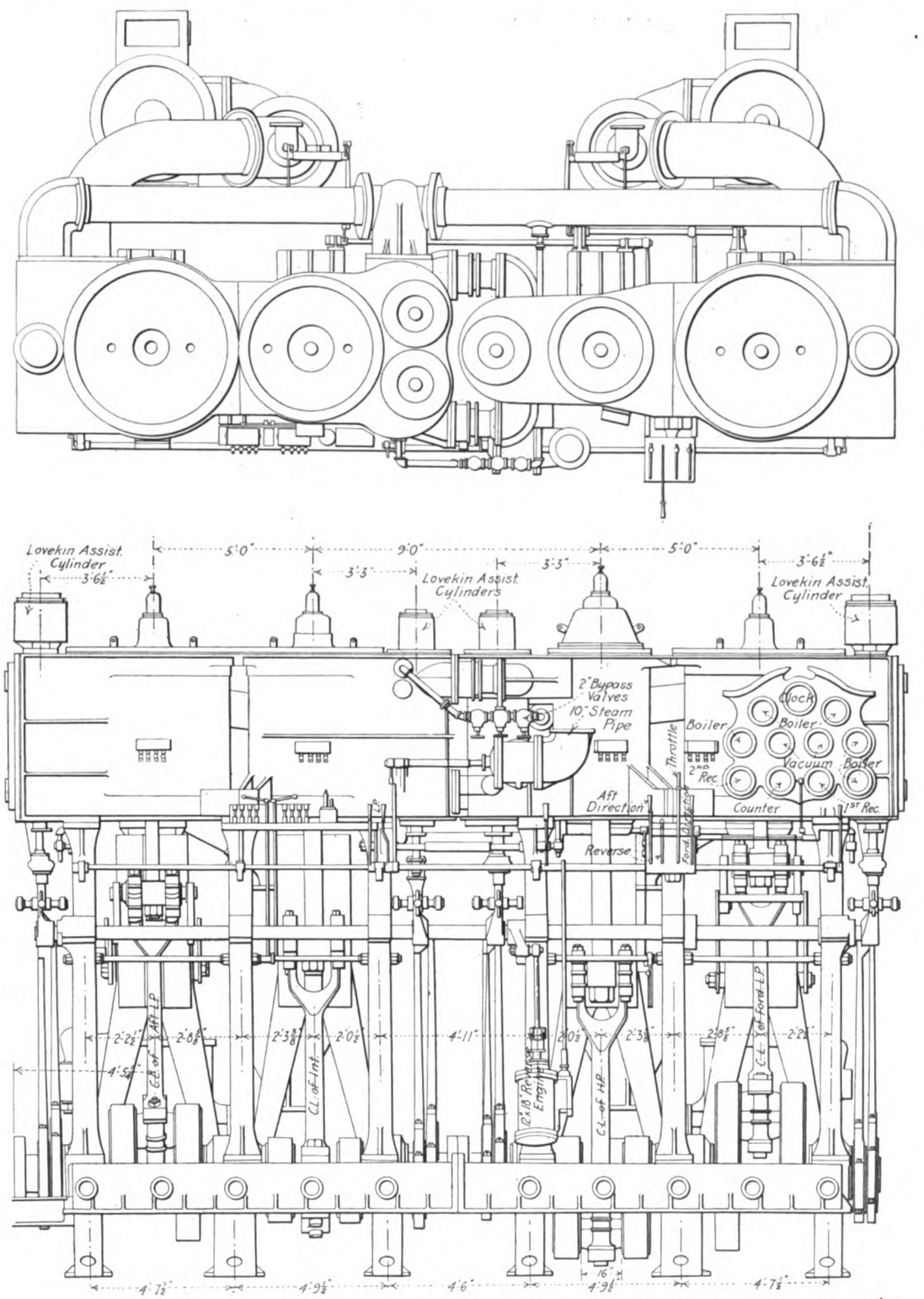

Fig. 4.—Main Engine, Designed to Develop 4,800 Indicated Horsepower

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it may be noted there is a complete absence of vibration in the ship.

The cylinders are arranged from forward to aft as follows: low-pressure, high-pressure, intermediate- and low-pressure, supported by four back columns and six front columns. The high-pressure cylinder has one balanced piston valve and the intermediate two, while the low-pressure cylinders have double-ported slide valves and relief frames, all valves being driven by Stephenson link motion and also being fitted with especially designed Lovekin patent assistant cylinders.

The back columns are of the inverted Y type, box section, and carry the guides and separate water backs. The front columns are of the I section, well ribbed and tied together. The bed plate is of the girder section, built in two sections and having six main bearings with removable cast steel shells lined with Phoenix metal. The thrust block is bolted to the bed plate and has bearings at each end and six horseshoe collars with liberal wearing surfaces. The thrust block, in addition to the usual dope cup lubrication, has a forced oiling system.

All pistons are cast steel, cone shaped, the high-pressure and intermediate having solid bull rings without piston rings, while the low-pressure pistons have two spring rings each. The piston rods are of steel, taper fitted to the pistons and crossheads and secured with nuts. The high-pressure and intermediate-pressure rods are 6½ inches diameter and the low-pressure rods are 5½ inches diameter. The crossheads are of the block type bolted to cast steel shoes which have slippers of brass with M & M metal. The connecting rods are mild steel forgings with forked top ends and adjustable brasses and tee-ended bottoms with cast steel boxes lined with Phoenix metal.

The propeller is sectional, 16 feet 6 inches diameter and 17 feet pitch, with cast iron hub and four cast steel blades with machined surfaces, all balanced in the shop. The expanded area is 87.22 square feet.

A departure from usual designs is shown in the air pumps, of which there are two, instead of the customary one, driven from the low-pressure crossheads. They are the Edwards patent type, 33 inches diameter by 15 inches

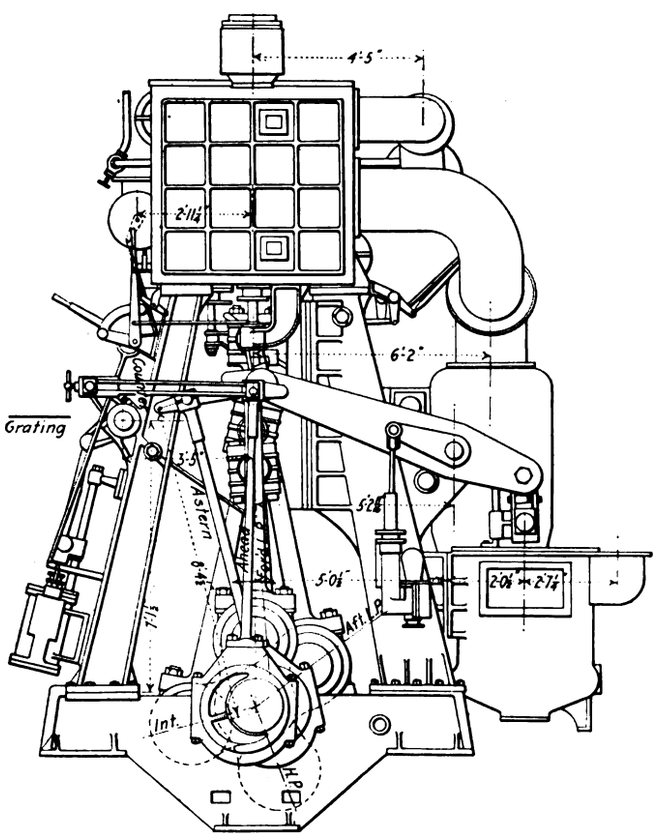

Fig. 5.—End View of Main Engine

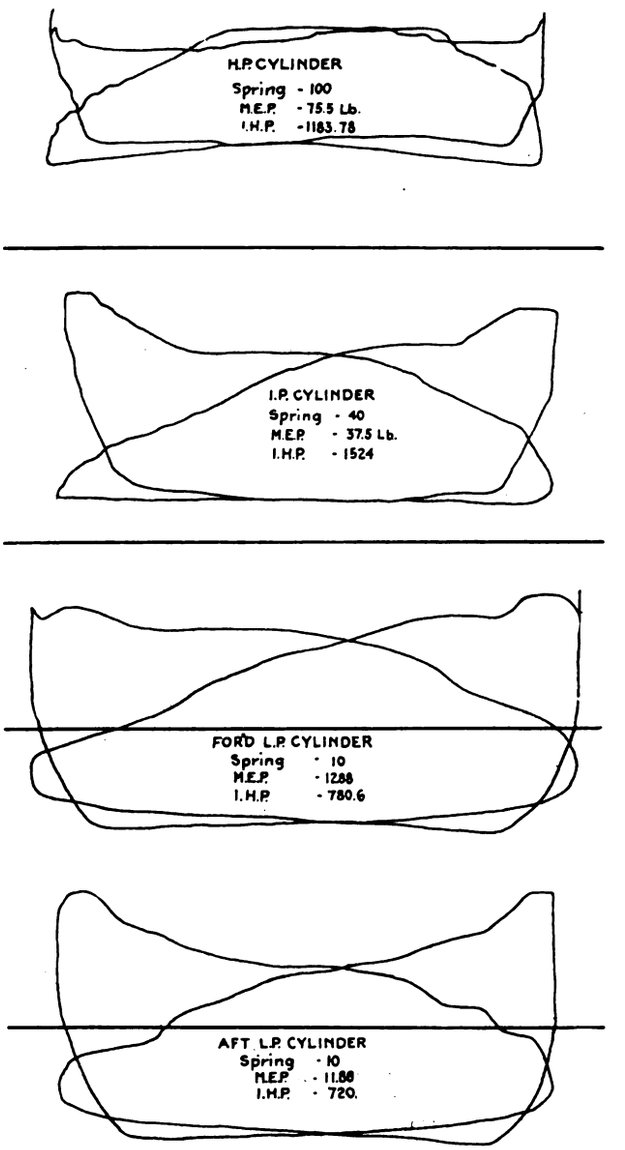

Fig. 6.—Indicator Cards Taken on Trial Trip. Total I. H. P., 4,209; Boiler Pressure, 195 Pounds; Vacuum, 24 Inches; R. P. M., 108

stroke, each working in connection with its own jet condenser. There are also fitted one bilge and one cooler pump, driven from each low-pressure engine.

The steam reversing engine is 12 inches diameter by 18 inches stroke and the steam turning engine is a double 4½-inch by 5-inch engine.

The engine is handled from a working grating at about the height of the reverse shaft, so that at all times the engineer can observe the working of his engine both below and above him, and has within his sight all gages and controls for pumps, etc.

Boilers

The steam generating plant consists of four main Scotch boilers and one donkey Scotch boiler. The main boilers

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are set in pairs with fire-rooms fore and aft. They are 15 feet 6 inches inside diameter, 11 feet long, built for 200 pounds pressure. Each boiler has three 48-inch diameter Morison furnaces.

An interesting feature of these boilers is the shell plate which is made in two plates only without the usual center girth seam, the length of the plate being 124¾ inches and the thickness 1 19/32 inches.

The donkey boiler is installed immediately forward of the main boilers and is 12 feet 6 inches diameter by 11 feet long and has two 48-inch diameter Morison furnaces. It also is similar in design to the main boilers, and is connected to the auxiliary steam pipes for use in port and also to the main steam pipe for emergency use. All boilers are connected to a common breeching and one smokestack, which is double, elliptical in form, the diameters being 13 feet 6 inches and 10 feet. The top of the stack rises 82 feet above the grates.

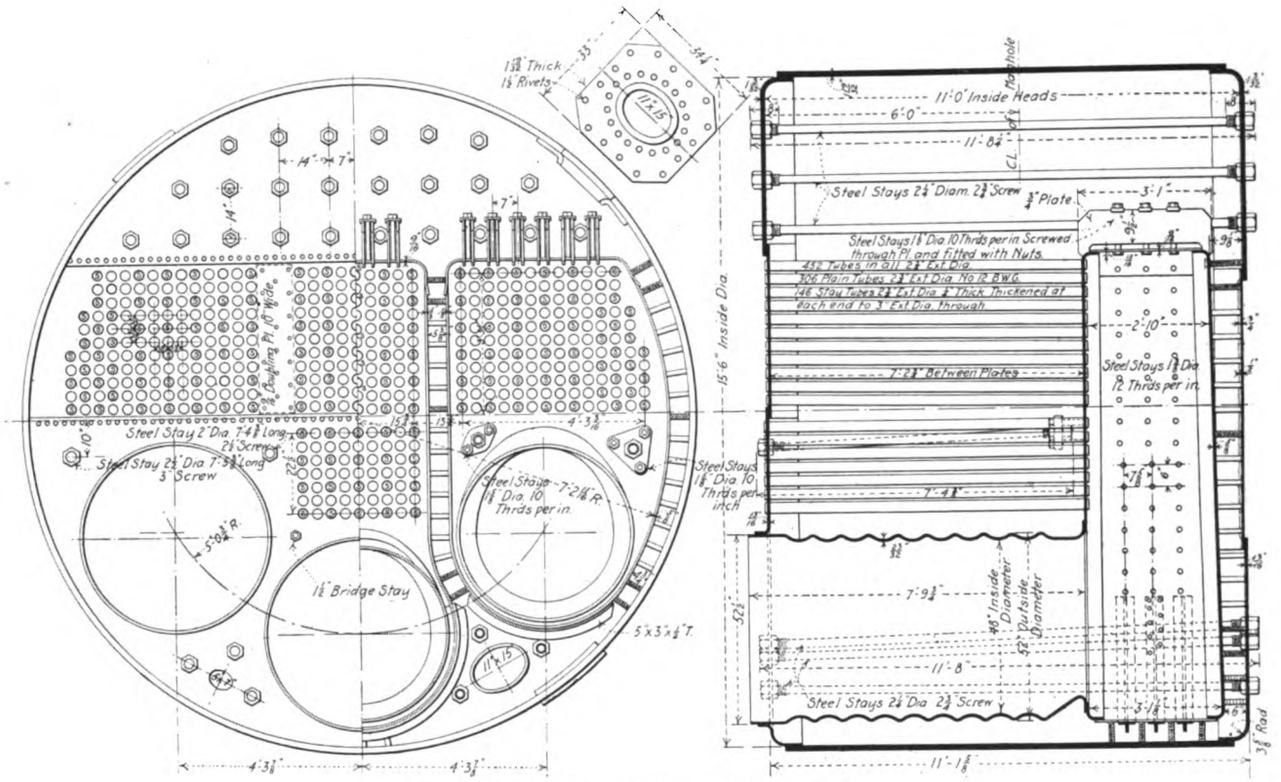
Manhole
11'-0" Inside Heads
6'-0"
11'-8¾"
Steel Stays 2¼" Diam. 2¾" Screw
¾" Plate
Steel Stays 1⅛" Dia. 10 Thrds per in. Screwed through Pl. and fitted with Nuts.
232 Tubes in all 2¾" Ext. Dia.
106 Plain Tubes 2¾" Ext. Dia. No. 13 B.W.G.
146 Stay Tubes 2¾" Ext. Dia. ¾" Thick Thickened at each end to 3" Ext. Dia. through
7'-2½" Between Plates
Steel Stays 1⅛" Dia. 12 Thrds per in.
15'-6" Inside Dia.
Steel Stays 1⅛" Dia. 10 Thrds per inch
7'-9¾"
48" Inside Diameter
52" Outside Diameter
11'-8"
Steel Stays 2¼" Dia. 2¾" Screw
3⅛" Rod
11'-1⅛"
1⅝" Thick 1⅛" Rivets
Steel Stay 2" Dia. 7'-4¾" Long 2½" Screw
Steel Stay 2¼" Dia. 7'-5¾" Long 3" Screw
Steel Stays 1⅛" Dia. 10 Thrds per in.
1⅛" Bridge Stay
5'x3'x⅜" T.
4'-3⅜"
4'-3⅜"

Fig. 7.—General Plans of One of the Main Boilers

Auxiliary Machinery

The main feed pumps are in duplicate, of the Weir vertical type installed on the engine room bulkhead immediately forward of the engine. They are of the piston pattern 12 inches by 8 inches by 24 inches single type, one pump being capable of feeding all five boilers while the other is held for emergencies. Particular care has been used in the feed lines in eliminating all right angle turns, there being no sharp angles in the pipe. The water is delivered to a horizontal Schutte & Koerting film feed heater with a capacity of 75,000 pounds of water at 210 degrees. There are also two 3-inch Metropolitan injectors for the main boilers and one 1½-inch injector for the donkey boiler. In addition to the above means of feeding boilers, the duplex fire pump, 12 inches by 6 inches by 12 inches, is also connected to the feed water heater. This pump also discharges to the fire line, pony feeds, condensers, ash guns and overboard for pumping the engine room bilges.

The sanitary pump is a duplex piston pattern 7½ inches by 8½ inches by 10 inches, connected to the sea and discharging to the sanitary system through a pressure regulating tank. There are three pumps installed for the water supply system, one for hot water, one for cold water and one for drinking water and kitchen service, all being duplex piston pumps 5¼ inches by 5 inches by 6 inches. The hot water pump draws from the sea and discharges to a water heater in which exhaust steam is circulated for heating the water and maintaining it at the required temperature. The cold water pump also has sea suction and discharges to fresh water tanks built into the ship abreast of the forward boiler room. These tanks are filled with pure water from Lake Superior only. From these tanks the fresh water pump takes its supply and discharges through a pressure tank to the fresh water system. All staterooms have running hot and cold water supplied by these pumps. Especial care has been taken with these systems to insure an absolute pure supply of water, and these pumps have no other connections which might contaminate the water.

The ballast pumps are two in number, duplex piston pattern 12 inches by 16 inches by 18 inches, each connected with a common manifold in the engine room through 12-inch suction pipes. From this manifold is led a 6-inch pipe to each ballast tank in the ship. The entire system of tanks contains 1,574 tons of water.

In addition to the foregoing pumps there is also installed a duplex piston pump 6 inches by 4 inches by 6 inches for mates' service, which is connected to both the fire line and the fire pump manifold. All these pumps are in the lower engine room and are of the Warren Pump Company make.

On the main deck in the engine room are two No. 8

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Sirocco fans, direct connected to 6-inch by 6-inch vertical engines for the Howden forced draft system. These fans have a capacity of 35,000 cubic feet of air per minute each. On this deck are also two Crocker Wheeler 50 kilowatt dynamos, direct connected to 9-inch by 8-inch American Blower Company engines and a complete switchboard controlling all circuits throughout the ship.

On the port side of the main deck is installed a Kroeschell refrigerating plant of 12 tons daily capacity.

One of the great features on this boat is the arrangement of steering gear. There are two engines installed of the direct acting type, both geared to the same quadrant. They are 9-inch by 9-inch American Ship Building Company engines, and are of the very latest design. One engine is in gear at all times, while the other is ready for use in emergency, and either engine may be thrown in or out of gear from the pilot house by means of a small steam cylinder geared to clutches on the engine pinions. The steam controlling valves of both the engines and clutch-shifting cylinder are operated by shafting from the pilot house, thus giving the wheelsman absolute control at all times of his steering gear.

Deck Machinery

The windlass is the American Ship Building Company 10-inch by 10-inch spur-geared type, with wildcats for 2⅛-inch stud link anchor chain. There are also fitted to the windlass two line spools for wire line which are used for mooring the bow end of the vessel if so required.

Other mooring gear is supplied by two double cylinder 8-inch by 10-inch American Ship Building Company deck engines, one fitted about amidship for mooring to either side, and the other fitted aft on the fantail.

The cargo-handling apparatus is interesting, being of the well-known type adapted to the lake trade. A 12-inch by 12-inch double steam engine is placed at the after end of the cargo hold and connected to a 3 7/16-inch shaft running to the forward end of the hold. On this shaft at each cargo hatch and gangway are two friction wheels which engage with drums 10 inches diameter and 3 feet 3 inches long, over which the hoisting tackle runs. The shaft is placed under the deck above the cargo hatches and is started when the cargo is to be loaded or unloaded, and runs continuously in the same direction, hoisting being accomplished by engaging one drum which revolves in the necessary direction and loading by engaging the adjacent drum.

For removing ashes from the fire room, four 7-inch hydraulic ash guns are fitted, discharging above the load waterline, each with large receiving hoppers with watertight covers.

On all the machinery throughout the vessel are fitted the necessary railings, gratings, safety guards, etc., and all modern devices found in an up-to-date ship are here serving the purposes for which they were intended. Besides this, the comfort and well-being of the crew have been attended to in the most approved manner. The accompanying plans show clearly the installation of the power plant.

Trial Data

The contract requirements specified by the owners called for an average speed of 16.65 miles per hour for a continuous run of six hours' duration with all usual auxiliaries running and with 1,500 tons of freight on board. The trial was to take place on Lake Huron on May 6, the course being laid from Thunder Bay Island, Mich., to Port Sanilac, Mich. Exceptionally rough and foggy weather, however, made it advisable to carry out the trials over a shorter course and in shallow water between Harbor Beach and Port Sanilac, a distance of 29 miles, going over the course until the six-hour run had been completed. During the trial two feed pumps, two blowers, two electric light engines, the hot and cold water and sanitary pumps, the steering engine and the ash gun pumps were running. A cargo of 1,696 tons was on board and the run lasted for six hours and thirty-five minutes. The following are the principal data from this run:

Displacement, gross tons	5,412
Area immersed midship section	776.5
Wetted surface, square feet	21,890
Draft, forward	11 feet 3 inches
Draft, aft	18 feet 1 inch
Draft, mean	14 feet 8 inches
Speed, miles per hour, average *	17.43
Slip of propeller, average †	11.6 percent
Steam pressure, average	192.71
First receiver pressure, average	73.05
Second receiver pressure, average	15.49
Vacuum, inches	23.93
Revolutions per minute, average	106.8
Indicated horsepower, high-pressure cylinder, average	1,169.6
Indicated horsepower, intermediate-pressure cylinder, average	1,505.7
Indicated horsepower, low-pressure cylinder aft, average	711.5
Indicated horsepower, low-pressure cylinder forward, average	771.2
Indicated horsepower, total, average	4,158
Mean effective pressure referred to low-pressure cylinder, pounds	34.2
Indicated horsepower per square foot grate	13.5
Square feet of heating surface per indicated horsepower	3.16
Temperature of injection water, approximate	40 degrees
Temperature of hotwell water, approximate	110 degrees
Temperature of feed from heater, approximate	200 degrees
Draft, inches of water at fans	3.73
Quality of coal	fair

* 17.71 miles per hour for four hours.

† Slip figured for speed of 17.71 miles per hour and 106.8 revolutions per minute.

The vessel ran in shallow water throughout the test and heavy winds with squalls prevailed, which was very disadvantageous to a speed test. It is estimated that with a proper depth of water and good weather conditions, the vessel can readily make a speed of 18 miles per hour or better.

The *Noronic* made her first trip of the season, leaving Cleveland, Ohio, on June 18, for Duluth and return.

First Year of the Panama Canal.—From August 15, 1914, to July 1, 1915, which constitutes the first fiscal year of the operation of the Panama Canal, a total of 1,088 vessels passed through the Canal, carrying an aggregate of 4,969,792 cargo tons. Five hundred and thirty of these vessels passed through the Canal from the Pacific to the Atlantic, and 558 went in the opposite direction. The receipts for the first year, August 15, 1914, to August 15, 1915, from tolls was $5,216,149 (£1,070,000), representing the passage through the Canal of 1,317 ocean-going vessels of a gross tonnage of 6,494,673 and a net tonnage of 4,596,644. That the traffic through the Canal is rapidly growing is shown by the fact that during July about 65 percent more vessels passed through the Canal than the average for the preceding months. The cargo carried through the canal during the month totaled 705,469 tons, which exceeds the shipments during any previous month. The tolls collected during the month amounted to $573,366 (£118,000).

New United States Battleships.—The plans for the two new battleships for the United States navy authorized by the last Congress were approved by the Secretary of the Navy on September 10. These ships will be 624 feet long over all, 600 feet long between perpendiculars, 97 feet 8 inches extreme beam, 30 feet mean draft, 20½ knots speed and about 32,000 tons displacement. The cost for each ship, exclusive of armor and armament, amounts to $7,800,000 (£1,600,000). The main battery of each vessel will consist of twelve 14-inch guns, and the secondary battery of twenty-two 5-inch rapid-fire guns and four submerged torpedo tubes. Bids for the construction of these vessels will be opened on November 17.

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Steamship Design

A Method of Determining the Principal Dimensions

BY H. A. EVERETT *

In the design of a merchant ship there are usually two or three items of prime importance, and the problem, in brief, consists of building the smallest vessel necessary to give these items. For example, in general, the amount of deadweight carry capacity, the speed and steaming radius are the items of first importance, for the first is the cause of being, so to speak, of the vessel and the others affect the carrying power throughout service.

These factors—carrying capacity, speed and fuel capacity—are usually stipulated by the owners, and from economic reasons purely; it is also common for owners to stipulate maximum draft, not from economic reasons, however, but from the nature of the harbors and docks to which the ship must have access when in service. The designer, therefore, is usually approached with the request to design a ship to carry so much cargo, to be able to go at a certain speed, and be able to make voyages to ports that are at so many knots distant.

In addition, it is stated that the vessel ought not to draw more water than a certain maximum draft, and in most vessels that are of good size this draft is accepted at once for the approximate draft of the ship, as in general, for the same carrying capacity and beam, the deeper draft ship will be cheaper both to build and maintain in service. This simplifies the problem materially, as it approximately fixes one dimension—namely, the draft.

In deciding upon dimensions which will be suitable for desired conditions there are several methods that are in common use. One consists in assuming a set of dimensions, sketching lines in accordance therewith, and on these estimating the weights of the various parts that make the complete vessel; if the displacement is not enough or too much to carry the estimated weights plus the cargo, the process is repeated. This method of trial and error, while perhaps the most common for the experienced naval architect, depends so entirely upon the data and experience of the designer that it is of but slight value in the hands of one of little experience.

Other methods rely upon some empirical formulæ to give the summation of weights which is to be balanced by the displacement, and in this general class is the one which will be used here. It is based upon the method outlined by Naval Constructor Woodward,† which has for its underlying principle the fact that the various coefficients of fineness of the boat, as block coefficient, etc., are functions of linear dimensions and that the stability of the ship is measured by the metacentric height which can be expressed as a function of the beam. All new designs must be governed by information regarding previous ships, as the combinations of length, beam and draft to give a certain displacement are infinite; and also any result which is arrived at as a first solution must be considered purely tentative, and should be but the basis of later refinement.

Consider now an actual case, the design of a vessel to fulfill the following requirements:

1—The hull shall be constructed of a certain type and material, the form being defined by the assumption of coefficients of fineness.

2—The vessel shall have machinery capable of giving her a speed on trial of S knots under customary trial conditions of fair weather, clean bottom, good coal, etc.

3—The vessel shall carry sufficient normal coal supply to have a radius of action of K knots at the above-named speed.

4—The vessel shall have capacity for carrying a certain deadweight composed of stores, fresh water and cargo, and also a certain hull outfit of a given weight, the above all totaling to the weight W.

5—The vessel shall have a certain metacentric height when at load draft.

The above requirements represent fairly the principal points to be considered in obtaining the first approximation to the principal dimensions.

The dimensions which are to be determined are:

L = the length of the immersed body in feet,
b = the maximum breadth of the immersed body in feet,
d = the mean draft of the immersed body in feet.

The mean draft considered is that of the immersed body proper, exclusive of any projecting bar or other keel.

The nature of the form of the immersed body of the vessel is defined by assuming the values of coefficients of fineness derived from those of a satisfactory vessel.

The coefficients of fineness used are:

α, *the block coefficient of fineness,* or ratio of volume of the normal displacement V to that of the circumscribed parallelopiped.

$$\alpha = \frac{V}{L\,b\,d}, \tag{1}$$

V being given in cubic feet.

β, *the cylindrical coefficient of fineness,* or ratio of volume of the normal displacement to that of the circumscribed cylinder.

$$\beta = \frac{V}{L\,M}, \tag{2}$$

M being the area of the immersed midship-section in square feet.

γ, *the coefficient of fineness of load waterline,* or ratio of area of load waterline to that of its circumscribed rectangle,

$$\gamma = \frac{A}{L\,b}, \tag{3}$$

A being the area of the load waterline in feet.

The first step in the determination of the principal dimensions is to establish two equations involving them, which may be called respectively:

(I) The equation of weights.

(II) The equation of stability.

Let us first consider Equation II, the equation of stability; it is necessary to deduce a relation between the general dimensions of the design which will fulfill the requirement that the vessel shall have a certain metacentric height.

The position of the center of gravity of the ship should

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† Proceedings of the Society of Naval Architects and Marine Engineers, Vol. I.

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be obtained by direct comparison with some other similar vessel, as it is treated as a function of the draft and is subject to considerable variation with different types of vessels.

It is assumed at a point G (Fig. 1) situated at a distance from the waterline

$$G\,O = v\,d. \tag{4}$$

v being a percentage depending upon the type of vessel. To obtain the position of the metacenter M it is necessary to express the distance $B\,O$ of the center of buoyancy from the load waterline, and the metacentric radius $B\,M$, in

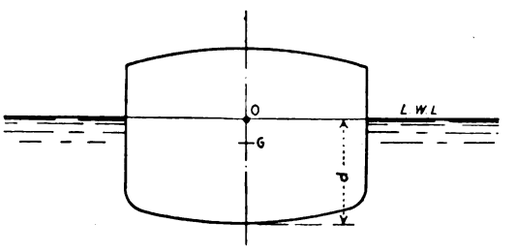

Fig. 1

terms of the principal dimensions and the coefficients of fineness of the design. The following formulæ, due to M. Normand, may be used for the purpose:

$$B\,O = \frac{d}{6} + \frac{\text{Vol.}}{3\,\text{Area}\,L.\,W.\,L.},$$

but as

$$\frac{\text{Vol.}}{\text{Area}\,L.\,W.\,L.} = \frac{\alpha\,L\,b\,d}{\gamma\,L\,b},$$

where

γ = coefficient of fineness of $L.\,W.\,L.$

we have

$$B\,O = \frac{d}{3}\left(0.5 + \frac{\alpha}{\gamma}\right) \tag{5}$$

The formula for metacentric radius is

$$B\,M = \left[0.008 + 0.0745\left(\frac{\text{Area}\,L.\,W.\,L.}{L\,b}\right)^2\right]\frac{b^3\,L}{\text{Vol.}},$$

and as

$$S = \gamma\,L\,b \text{ and Vol.} = \alpha\,L\,b\,d,$$

we have

$$B\,M = \left[0.008 + 0.0745\,\gamma^2\right]\frac{b^2}{\alpha\,d}. \tag{6}$$

The equation of stability which expresses the requirement that the vessel shall have a certain metacentric height ($G\,M$) (Fig. 2) may, therefore, be written

$$GM = BM - (BO - GO), \tag{B}$$

and substituting in this the values derived above, we get

$$GM = (.008 + .0745\,\gamma^2)\,\frac{b^2}{\alpha\,d} - \left[\frac{d}{3}\left(\frac{1}{2} + \frac{\alpha}{\gamma}\right) - vd\right] \tag{7}$$

solving for b in terms of d

$$b = \sqrt{\frac{\frac{\alpha\,d^2}{3}\left(\frac{1}{2} + \frac{\alpha}{\gamma} - 3\,v\right) + \alpha\,d \times GM}{.008 + .0745\,\gamma^2}} \tag{8}$$

It is desirable here to consider the comparative accuracy of the two formulæ that form the basis of the equation of stability.

The expression for the vertical position of the center of buoyancy is usually correct to one-half of one percent of the mean draft. That of the metacentric radius $B\,M$ is by no means as accurate, and the expression for $G\,O$, or the location of the center of gravity of the hull, is the least satisfactory, as the variation with different types of vessels is large. With information concerning similar ships, however, the formula gives good results, and has

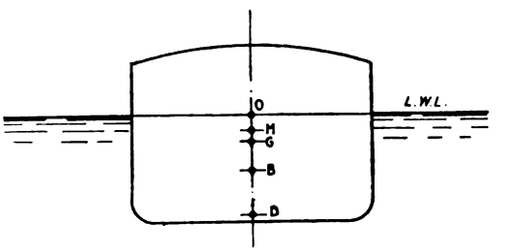

Fig. 2

the merit of being logical and of taking cognizance of the question of stability at the beginning of the design, which is not true of some methods of determining the important dimension of beam.

Consider now the equation of weights (I):

Let D = normal displacement of the ship in tons,
h = weight of hull and fittings in tons,
m = weight of machinery in tons,
n = weight of normal coal supply in tons,
W = weight of cargo, fresh water, stores and hull outfit in tons.

Then, evidently,

$$D = h + m + n + W. \tag{9}$$

Consider the right-hand member of this equation in detail.

Weight of Hull

The weight of hull and fittings may be considered as a certain percentage of the normal displacement. As with many of the other percentages which are hereafter assumed, it presupposes at least an approximate knowledge of the very dimensions which are to be determined, and of the general method of construction and material to be used in building. Calling δ the value of this percentage, the weight of hull and fittings is given by

$$h = \delta \times D. \tag{10}$$

Weight of Machinery

To estimate the weight of machinery it is necessary to first make an approximation to the indicated horsepower P required to propel the vessel at the speed S. To do so we use the Admiralty displacement coefficient,

$$B = \frac{D^{2/3} \times S^3}{P}. \tag{11}$$

B is the Admiralty coefficient, a coefficient of performance based on the trials of ships of similar form. It varies with the dimensions, form and speed adopted, in general from about 250 to 300.

If p is taken as the number of horsepower per ton of

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machinery for the type of engines and boilers which it is intended to employ, the total weight of machinery m is evidently by (11)

$$m = \frac{P}{p} = \frac{D^{2/3} \times S^3}{p \times B}. \qquad (12)$$

WEIGHT OF COAL

The normal coal supply (n) required to give the vessel a steaming radius of K knots at the speed S may be considered as composed of the coal used in the actual propulsion of the ship, and that used in the various auxiliary services of heating, electric lighting, galley, distilling, steering gear, ventilating blowers, etc. The consumption of coal for the auxiliaries may be assumed to be approximately independent of the speed and equal to g pounds per hour. Designate by c the coal consumption of main engines with dependent auxiliaries in pounds per indicated horsepower per hour at the speed S.

The coal used in propelling vessel in tons per hour is, therefore,

$$\frac{c}{2{,}240} \times P = \frac{c \times D^{2/3} \times S^3}{2{,}240\, B_2}. \qquad (13)$$

Multiply this by $\frac{K}{S}$ to have total amount for the distance K, since the number of hours' steaming will be $K \div S$.

The coal used in auxiliary steam services is

$$\frac{g}{2{,}240} \times \frac{K}{S}. \qquad (14)$$

Therefore, the normal coal supply is expressed by

$$n = \frac{c \times D^{2/3} \times S^3 \times K}{2{,}240\, B \times S} + \frac{g\, K}{2{,}240\, S}. \qquad (15)$$

While the hull weight can be fairly satisfactorily represented as a function of the displacement, the hull outfit is, practically, independent of size, being more dependent upon the type of ship and service it is to engage in. In this should be included such items as carpenter and joiner work, wood decks, lighting, ventilation fittings, rigging and spars, deck machinery and installations for heating, ventilating, refrigeration and generation of electricity, including the auxiliary boiler. Thus it can be readily seen that a close estimate can better be made by *estimating outright* the hull outfit, knowing the conditions the ship is to work under, than to attempt to represent it as a function of hull displacement. It can then be added to the required cargo and treated as a fixed weight.

Now, the displacement must equal the sum of the various weights, so that the equation of weights is

$$D = h + m + n + W,$$

which may, therefore, be rewritten as follows:

$$D = \underset{\text{(hull)}}{\delta\, D} + \underset{\text{(machinery)}}{\frac{D^{2/3} S^3}{p\, B}} + \underset{\text{(normal coal)}}{\left[\frac{c\, D^{2/3} S^3 K}{2{,}240\, B\, S} + \frac{g\, K}{2{,}240\, S}\right]} + \underset{\text{(fixed wts.)}}{W} \qquad (16)$$

or arranging the terms of the equation according to powers of D,

$$D\,(1-\delta) = D^{2/3}\left(\frac{S^3}{p\, B} + \frac{c\, S^2 K}{2{,}240\, B}\right) + \frac{g\, K}{2{,}240\, S} + W \qquad (17)$$

But 35 cubic feet of sea-water weigh, approximately, one ton, or 35 $D = V$, and, substituting in (17) the value of D,

$$D = \frac{V}{35} = \frac{\alpha\, L\, b\, d}{35},$$

and arranging the terms according to powers of L,

$$L\, b\, d\,(1-\delta) - L^{2/3}\,(b\, d)^{2/3}\left(\frac{35}{\alpha}\right)^{1/3}\left(\frac{S^3}{p\, B} + \frac{c\, S^2 K}{2{,}240\, B}\right) - \frac{35}{\alpha}\left(\frac{g\, K}{2{,}240\, S} + W\right) = O \qquad (18)$$

This may be considered an equation of the form

$$L + L^{2/3} + y = O \qquad (19)$$

$$\text{where } N = -\frac{(d\,b)^{2/3}\left(\frac{35}{\alpha}\right)^{1/3}\left(\frac{S^3}{p\, B} + \frac{c\, S^2 K}{2{,}240\, B}\right)}{(1-\delta)\, b\, d} \qquad (20)$$

$$y = -\frac{\frac{35}{\alpha}\left(\frac{g\, K}{2{,}240\, S} + W\right)}{(1-\delta)\, b\, d} \qquad (21)$$

The solution of the equation (15) is given by

$$L = \left[-\frac{x}{3} + \sqrt[3]{-\frac{y}{2} - \frac{x^3}{27} + \sqrt{\frac{y\,x^3}{27} + \frac{y^2}{4}}} + \sqrt[3]{-\frac{y}{2} - \frac{x^3}{27} - \sqrt{\frac{y\,x^3}{27} + \frac{y^2}{4}}}\right]^3 \qquad (A)$$

in which the value of L is expressed directly as a function of b and d; this equation being obtained, as has been seen, by stating analytically the fact that the volume of water which the ship displaces has a weight equal to that of the hull and its contents.

The solution for length from formula A is entirely valueless unless seven-place logarithms are used and accurate interpolation made, as we are dealing in the last term with the very small difference of two large quantities. There is, however, a rearrangement possible which will permit the use of five-place logarithms as follows:

The second term is rearranged and the difference is expressed so as not to involve a direct subtraction and a value for the entire cube root expression obtained. The second cube root is of the form

$$\sqrt[3]{A} - \sqrt{B} \text{ if we let } A^2 - B = \Delta$$

then

$$(A - \sqrt{B})\,(A + \sqrt{B}) = \Delta$$

$$(1) \text{ and } (A - \sqrt{B})^{1/3} = \left(\frac{\Delta}{A + \sqrt{B}}\right)^{1/3}$$

In the right-hand member there is a sum of two quanties instead of a difference. The value of Δ in terms of x and y is (from equation A)

$$\Delta = A^2 - B = \left(-\frac{y}{2} - \frac{x^3}{27}\right)^2 - \left(\frac{x^3 y}{27} + \frac{y^2}{4}\right) = \frac{y^2}{4} + \frac{y\,x^3}{27} + \frac{x^6}{27^2} - \frac{x^3 y}{27} - \frac{y^2}{4}$$

therefore

$$\Delta = \frac{x^6}{27^2}$$

inserting this in (1) and substituting in A the following is obtained:

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$$L = \left[-\frac{x}{3} + \sqrt[3]{-\frac{y}{2} - \frac{x^3}{27} + \sqrt{\frac{y x^4}{27} + \frac{y^2}{4}}} + \sqrt[3]{\frac{x^6}{729}} \right.$$
$$\left. + \sqrt[3]{-\frac{y}{2} - \frac{x^3}{27} + \sqrt{\frac{y x^4}{27} + \frac{y^2}{4}}} \right]$$

Five-place logarithms will be sufficiently accurate for the solution of this expression.

If preferred, the cubic equation (18) or (A) may be solved graphically by selecting several trial values for L, plotting the results and interpolating for the value, which satisfies the equation.

The resultant equations for length (A) and stability (B) express the relations that must exist between the three unknown quantities L, b and d, if the equations of weight and stability are to be fulfilled. There are, therefore, an unlimited number of possible solutions, and, in order to determine a particular solution, some further requirement must be adopted.

In the case in hand it will be the assumption of a limiting draft. This requirement is in the nature of a limit which must not be surpassed, but which need not necessarily be attained; even in the general case where no limit is put upon any particular dimension by the requirements of the future service of the vessel. Limits are implicitly given by the fact that the various coefficients of weight of hull, machinery, coal consumption, propulsion, utilization, etc., which have been assumed in the formation of the two equations of condition, can only be considered as constant for moderate variations in the dimensions. It is, therefore, necessary to observe the influence of small changes in the principal dimensions.

For a merchant ship draft is the dimension in general which is defined between the narrowest limits, so that in the solution of the problem it will be well to assume several drafts and solve for the other dimensions. Probably the methods can best be followed by a concrete illustration, for which the following will suffice.

Problem in Ship Design

To obtain the dimensions of a vessel to fulfill the following conditions:

1—To carry 9,163 tons of cargo, fresh water and stores and an outfit of 963 tons.
2—To have a mean draft of not more than 28 feet.
3—To have sufficient power to make a speed of 13 knots.
4—To be able to steam 3,400 knots at a speed of 13 knots.
5—To have a metacentric height (GM) of 2 feet.
6—The vessel is to be of the double-bottom, shelter-deck type, built to the requirement of Lloyd's.
7—The cargo to be general merchandise.

In addition to the above data, which are determined from commercial and route conditions, it is necessary to assign factors of fineness, power and weight; and while the choice of proper values of these presupposes to a certain extent knowledge of the final dimensions, yet within narrow limits proper values can be assigned from the naval architect's experience with ships of a similar nature built for similar trade and conditions. Accept, then, the following constants as the data at hand:

α—Block coefficient	.778
γ—Load waterline coefficient	.879
β—Prismatic coefficient	.804
α/β—Mid-section coefficient	.968

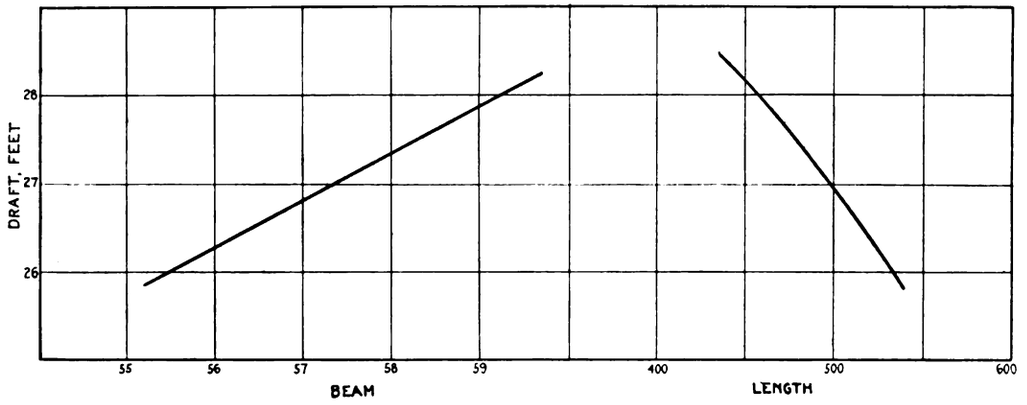

Fig. 3

δ—Hull weight coefficient	.280
v—Center of gravity coefficient	.155
C—Coal per horsepower-hour	2.0
q—Auxiliary coal per hour	.800
B—Admiralty coefficient	.293
p—Horsepower per ton machinery	4.81

As the maximum draft allowed was given as 28 feet, this will be accepted for the first solution for beam, and substituting this in equation (8), we get

$$b = \sqrt{\frac{\frac{\alpha d^2}{3}\left(.5 + \frac{\alpha}{\gamma} - 3v\right) + \alpha d \times GM}{.008 + .0745\gamma^2}}$$
$$= \sqrt{\frac{\frac{.778 \times 28^2}{3}\left(.5 + \frac{.778}{.879} - 3 \times .155\right) + .778 \times 28 \times 2}{.008 + .0745 \times .879^2}}$$
$$= 59.27 \text{ feet.}$$

Five-place logarithms can be used in this solution, but anything less refined is undesirable.

This now gives a beam which is in agreement with the 28-foot draft assumed; and, using these two quantities, solution can be made for the length from equation (A) giving L in feet. This should be repeated for two more solutions at drafts which are successively different by perhaps .5 foot and the results expressed either in tabular form or by curves similar to Fig. 3; then for any desired draft the other dimension in agreement therewith can be read off.

From this information, then, the most desirable combination of length, breadth and draft can be selected,

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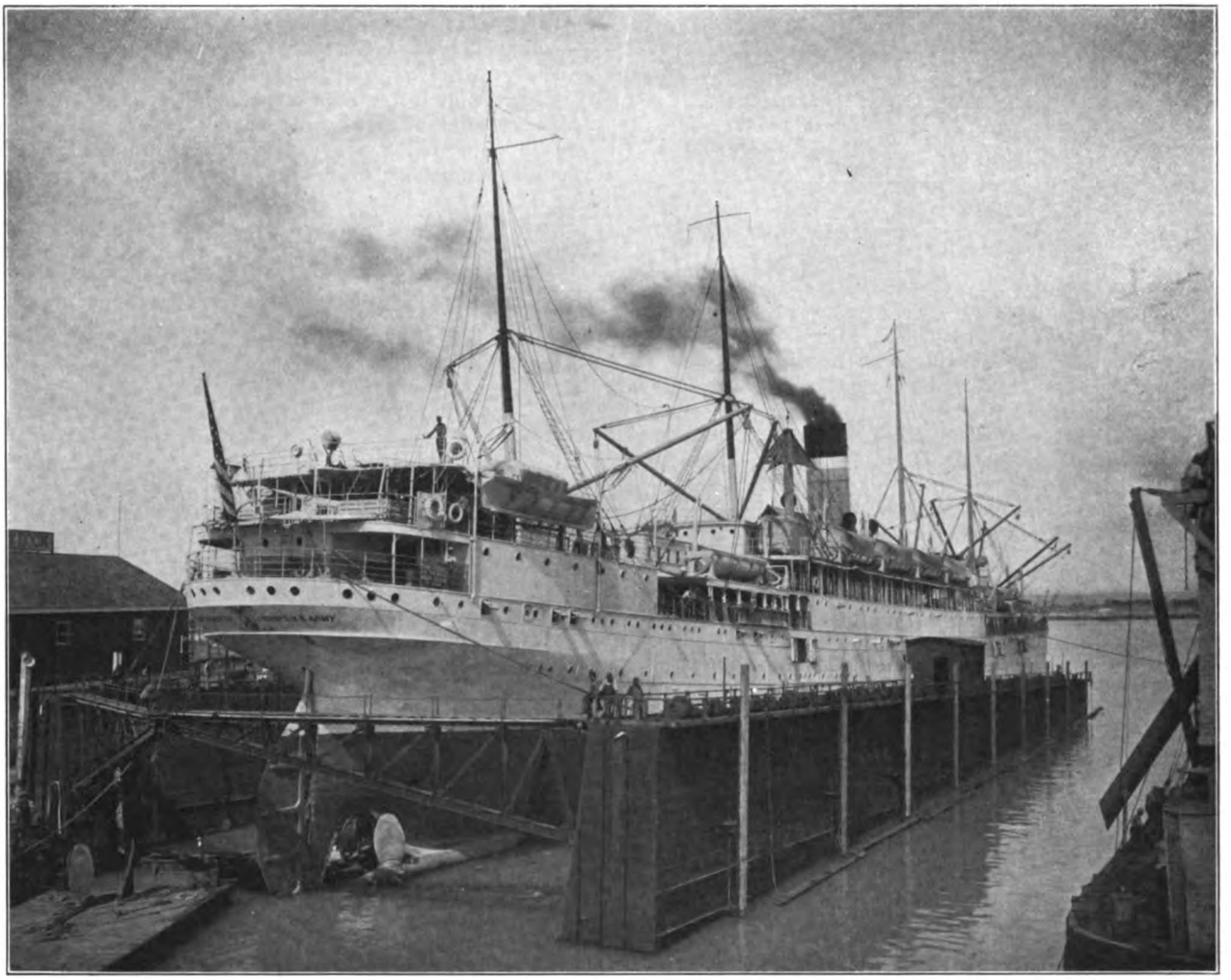

Fig. 1.—Army Transport *Thomas* in Honolulu Floating Dry Dock

taking into consideration cost of building, strength, resistance, etc.

So far, no consideration has been given to the question of depth except as involved in the constants selected; but, as depth is equal to draft plus freeboard, the freeboard should next be determined,† taking account of the characteristic features of the hull.

It is obviously highly desirable that a systematic record be kept of designs carried to completion, as only in this way can the constants be satisfactorily estimated for a new design. In general, however, they lie between the limits given below:

Block coefficient (α) .60 — .75 (passenger) .75 — .83 (freight).

Load waterline coefficient (γ) .75 — .85.

Prismatic coefficient (β) .63 — .78 (passenger) .78 — .86 (freight).

Midship section coefficient .95 — .99.*

Hull weight coefficient (δ) .25 — .30.

Center of gravity coefficient (v) .13 — .19.

Coal per horsepower-hour 1.5 — 2.0 (including dependent auxiliaries).

Admiralty coefficient 235 — 290.

Horsepower per ton of machinery, 4.85 — 5.00 freight; 5.00 — 6.00 transatlantic passenger; 6.00 — 7.00 intermediate cargo passenger (large size).

* Present information indicates that the large values are good from a resistance point of view.

† An article on the preliminary determination of freeboard will appear in a subsequent issue.

Replacing Propeller of Vessel of Over 11,000 Tons Displacement in Floating Dry Dock with a Lifting Capacity of only 4,500 Tons

On August 12 the United States Army transport *Thomas*, which is 470 feet 6 inches long overall with a beam of 50 feet 2½ inches and an approximate displacement of 11,050 tons on a draft of 24 feet, was placed in the floating dry dock of the Inter-Island Steam Navigation Company of Honolulu, which is only 352 feet long overall and has a lifting capacity of only 4,500 tons. The *Thomas* was crippled by the breaking of the blades of one of her propellers. As shown by the illustrations, she was placed in the floating dry dock and the stern raised until the propellers were out of water. Between midnight on August 12 and 8 P. M., August 13, three blades of one propeller were removed and new blades substituted, allowing the vessel to proceed on her way with only one day's delay.

It is apparent that as the length of the dock is only 352 feet and the length of the ship 470 feet 6 inches, the bow of the ship overhung the dock 118 feet 6 inches. By a careful inspection of the photographs, it will be seen that the bow was hardly lifted while the stern of the vessel was lifted approximately 20 feet. From this it will be seen that it is practicable to make propeller repairs on a very large steamer with the aid of a comparatively small

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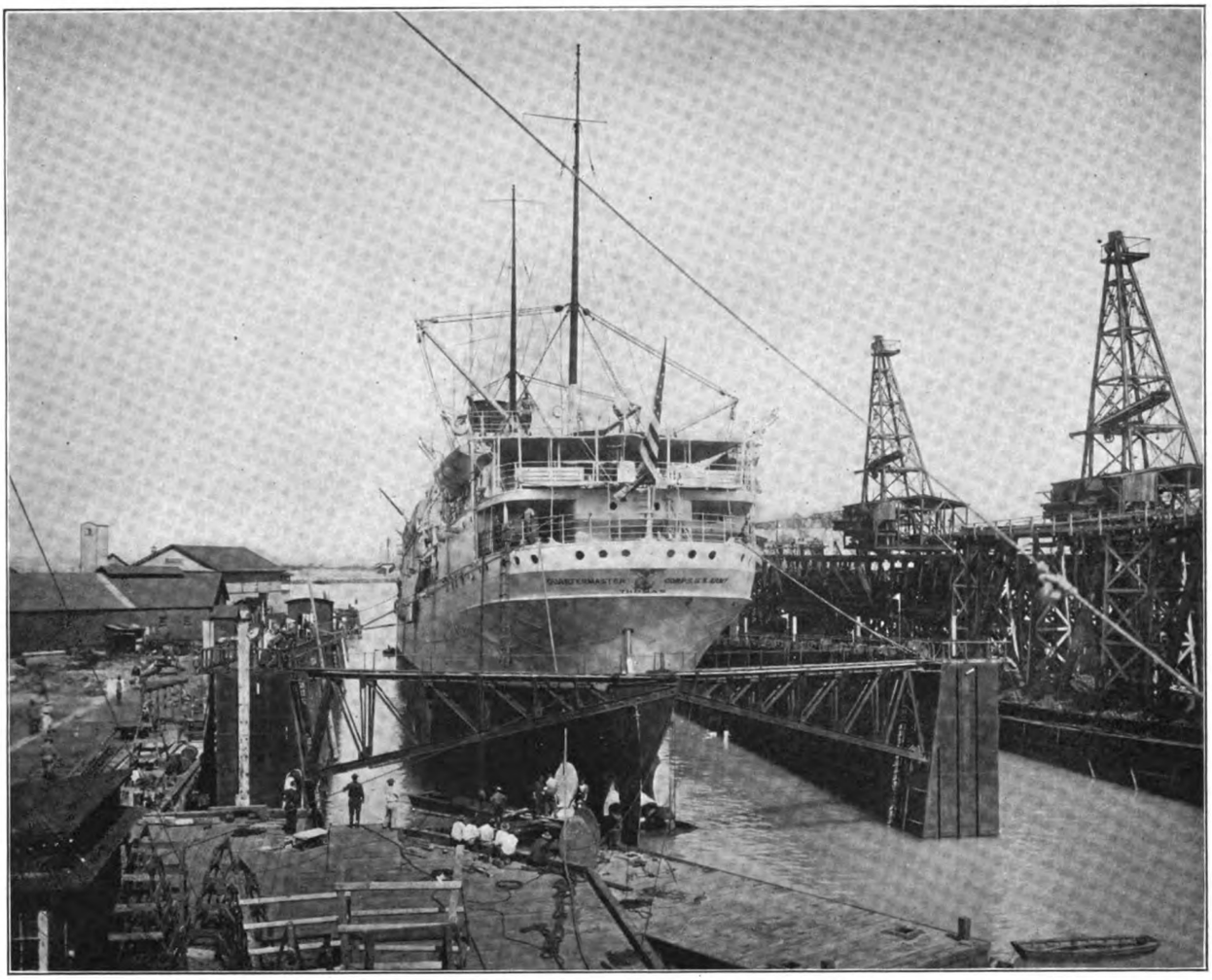

Fig. 2.—Replacing Propeller Blades on Army Transport *Thomas*

floating dry dock. This dock was designed by William T. Donnelly, consulting engineer, New York, and in our July, 1914, issue it was fully described, together with a description of the docking of a large caisson which was an exceedingly top heavy structure. These two instances of unusual docking operations give a good idea of the wide range of usefulness of dry docks of this description.

The Classification of Ships

BY ARTHUR R. LIDDELL

American shipowners have sometimes asked what they gained by the classification of their fleets. The usual answers given have been that the registration society exercises a control by impartial surveyors over the construction of the ships and carefully tests the material supplied by makers, and that underwriters regulate their policies in accordance with the classes given. It is sometimes objected that a high-class shipyard can offer the same advantages in these respects, but a little consideration ought to show that this is hardly the case. The control has to be exercised by somebody, and to hand it over to an impartial central body is the cheapest way of carrying it out. The formation of a correct judgment on the scantlings of a vessel that departs to any considerable degree from ordinary types requires a good deal of special knowledge which is not easily acquired. The average chief draftsman has not had the opportunity of seeing more than a certain range of work. If shipbuilders are to exercise this judgment, they must keep specialists to support them. In place of two or three men in the head office of a registration society, the shipping industries must pay the salaries of an expert in the branch in question in each of the shipyards, and, moreover, these experts cannot be expected to work on uniform lines.

The testing of the material is done by the registration societies' surveyors at the makers' works. Any material not up to the standard is stopped at once, and time and friction are saved. If ten shipyards each send a surveyor to do this work, these representatives spend a large part of their time in waiting till portions of their material—sometimes very small ones—are ready for test, whereas a single local testing surveyor of a registration society can deal with one batch after another for different yards. His work costs much less than that of the ten shipyard men and his special experience should enable him to act with greater confidence and authority. If the material is to be tested on delivery, each shipyard must have a testing plant and specialists to use it. Faulty material must be returned, and either the arrival of fresh material awaited or large losses incurred by the substitution for it of unsuitably dimensioned stock. The cost of transport of faulty material, which is considerable, will in the long run have to be borne by the shipping industries in general, though for the moment it may fall on the steel maker alone.

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Then, again, there is the control of the building of the ship. The owners' ship surveyor is often a seaman. If he be a naval architect, he will probably be wanting in the desirable quality of sea experience. The seaman may have a carpenter to assist him, but neither seaman nor carpenter will have the requisite special knowledge of materials or of the functions of the different parts of a steel structure. The shipyard also has not always at its command men trained to look at questions of local strength from the required point of view. There again each ship owner must have a specialist on the spot, and the combined salaries of these represent a much greater sum than the cost of control by the local surveyor, who, by the way, finds time to perform other duties as well.

Decisions given by an impartial authority are, in general, likely to be accepted. Controversies are thereby avoided and friction minimized. The question, what strength—i. e., what scantlings—should be given to a proposed vessel, is a very difficult one. A method of gaging it that can be simply applied has not yet been found. The mere application of the rules and tables of the registration society is not in itself sufficient. Any ship that is out of the common run has to be specially treated, and the scantling finally adopted for her is generally the result of special consultation and agreement with one of the bodies that have had a lifelong experience of strength questions and can speak with authority in regard to them. The certificates of such bodies also lighten the responsibility that has to be borne by shipowner and shipbuilder in case of accidents to their vessels. The public is an exacting tribunal and shows no mercy to the owner or builder of a ship that suffers mishap.

It is said that underwriters are prepared to take risks on unclassed vessels. This is, under certain conditions, no doubt correct, but that the possession by a ship of a high class in a good registration society would not tend to lower the premium has to be demonstrated. The underwriter adjusts his premiums in relation to a number of different conditions, and he will probably in all cases be guided to a certain extent by the class or the want of it, even though he does not say so.

But there is yet another side to the business of the registration society, and that is the keeping of the vessels up to the mark as the years roll by, the eventual lowering of their classes on account of deterioration, and the ordering of necessary repairs when a ship seeks port in a battered condition after a storm. This work can be satisfactorily and systematically performed only by a staff of surveyors at the outports who stand under instructions from headquarters and are supplied with all the dates of previous surveys and with the particulars of previous cases of damage experienced by each ship in question.

Finally, when a vessel is to be sold, perhaps to make way for a more up-to-date successor, she is more likely to command a good price if classed than if entirely without a certificate.

A registration society that is wise in its generation and takes an intelligent view of its position and its sphere of action is the friend and advisor of all shipping men. In their register books the societies compile a mass of useful information that is nowhere else attainable, and they supply the sea interests with networks of facilities and with ready advisors who are depositories of general and local information at all frequented corners of the earth. To make use of the work and experience embodied in their rules without supporting them would ultimately be to let rules and register book and all the advantages provided by them go by the board and create the necessity for the uncompromising and undifferentiating government supervision that has in all ages been deprecated and avoided. The practice of dispensing with classification leads entirely in this direction. With the first great mishap, Judge Lynch steps in. Previous high reputations of firms involved are disregarded, and ignorance decrees that perfect safety shall in future be seen to by the nation. But the nation means retired public servants, who will go sure—that is to say, who will set their faces against improvements or developments in every form, because they cannot gage their consequences. The registration society is the outcome of the accumulated professional experience of the shipbuilding, shipowning and underwriting communities, which it focuses and renders accessible to all. It has no interest in the running of risks, and concessions it may make to any client are jealously watched by the rest. Any forward move it may sanction is certain to have been viewed in every possible light, and, in fact, it exercises the same guiding and moderating influence in the shipping industries that an upper chamber of the legislature does in general politics. To replace it by a public department would be to discard the safety valve and work the boiler at half pressure.

It is, indeed, a question for mature consideration, whether the functions of the registration societies could not profitably be further extended so that these bodies exercise more influence than at present on the various sea qualities of the ships they class. In connection with stability, rolling, steering, tendency to ship seas, vibration, arrangement of weights, stowage and some other qualities, there are limits and danger-zones that are, unfortunately, not matters of common knowledge. They might be made so by the training of the rank and file of men engaged in the shipping industries to a higher degree than at present. To do this, however, would be a work of time, and it would cost money. The students of naval architecture at the Technical College in Charlottenburg some years ago issued a pamphlet of warning against overcrowding of their faculty. In this it was shown that the college training cost at least M10,000 per man and lasted some four or five years, and that the posts that might satisfy the aspirations of the successful students were few in number and, owing to concentration of work in large establishments, were becoming still fewer. A minority only of the certificated ones could ever reap the advantages of the money and time spent on their education. In fact, unlimited higher education does not pay, and we are forced back to the old system of the division of labor. Societies with special functions and practically acting as committees of the representatives of the sea industries can exercise sufficiently elastic control over current practice to the best advantage of all concerned.

MONTHLY SHIPBUILDING REPORT.—The Bureau of Navigation reports 94 sailing, steam and unrigged vessels of 15,410 gross tons built in the United States and officially numbered during the month of August. Of these vessels, 13, aggregating 8,669 gross tons, were steel steamships. The largest vessel completed during the month was the steamer *W. F. White* of 7,180 gross tons, built by the American Shipbuilding Company at Lorain, Ohio. Four foreign-built vessels, of 12,509 gross tons, were added to the American merchant fleet during the month.

The steamer *Rose City* of the Portland & San Francisco Steamship Company, Portland, Ore., will be equipped with four Ballin watertube boilers and other equipment at a cost of $50,000 (£10,500).

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Calculations for Ships' Forms*

Light Thrown by Model Experiments Upon Resistance, Propulsion and Rolling of Ships

BY REAR ADMIRAL D. W. TAYLOR†

All ship calculations proper are made from the complete lines, namely, sheer, half-breadth and body plans, or from special calculation plans derived from the lines. But in order to get out the lines in the first place, the usual methods of trial and error involve a large amount of calculation. Such drudgery could be largely reduced by the determination, once for all, before delineation, of each line to be drawn, provided this determination did not bring in too much drudgery of its own. This leads to the use of mathematical formulæ of such nature and with such optional coefficients as to enable us to choose in advance the kind of line we wish, with the certainty that the displacement or area will be what is desired. Some devices or formulæ for lines propose to go further and give lines resulting in ships particularly easy to drive, or whose resistance can be calculated from coefficients depending upon the formulæ. Such a proposition, for instance, was put forward by Herr Bauer in 1914 before the Schiffbautechnischen Gesellschaft.[1]

For some fifteen years, at the U. S. Model Basin, there have been used mathematical formulæ, not with the idea that they give lines of minimum resistance, but simply to obtain lines possessing desired shapes. Dealing with a large number of models annually—one hundred and fifty distinct models in some years—even after allowing for the fact that many of them are from complete sets of lines furnished independently or derived from other lines by expansion or contraction, it would be practically impossible to accomplish the work with the force available, if it were necessary to draw each new set of lines by the trial and error method. By present methods, after a little study and practice, a competent draftsman can get out a complete set of lines giving exactly the displacement desired, using nothing from any previous vessel, in not more than five days. Most models, however, are modifications, in a desired direction, of some previous lines, and can be gotten out in less time. Practically all United States naval vessels designed during the last ten years have had mathematical lines.

Formulæ for lines should be as simple as possible and involve the fewest possible optional coefficients. This for the reason that these quantities are not wholly independent, and the more complicated the formulæ and more numerous the optional quantities, the more complicated the relations between the optional quaitities which must be considered in obtaining a fair form. For water lines and curves of sectional area we use a fifth-power parabola as the primary formula. For such a line, of given half-length and half-beam, we may choose, at will, the coefficient of fineness, the tangent or angle of inclination at the extremity, and the curvature amidships. The inclination at the midship section is in every case zero, and the water line must have the proper half-breath at the midship section, which, of course, is not necessarily at the center of length.

For fine sections, with sectional coefficients below 0.7, or thereabouts, a fourth-power parabola is used, the optional quantities being the coefficient of fineness of the section, the flare or tumble-home of the section at the water line, and the dead-rise at the keel. For full sections, with sectional coefficients above 0.7, or thereabouts, we use an arc of a very well-known curve, namely, the common hyperbola. This can be made to give sections practically identical with those from the fourth-power parabola for coefficients in the vicinity of 0.7, so we can pass from one formula to the other without any difficulty. For these full sections the only optional quantities are the coefficient of fineness and the flare or tumble-home at the water line. The dead-rise follows from the nature of the curve, but it is found in practice that for the full sections for which the hyperbola is used, and for ships' forms as they are, the dead-rise angles resulting from the hyperbola are quite satisfactory. The trouble with mathematical formulæ for sections and water lines is that in addition to giving us the curves we want, they are capable of giving us a great many curves that we do not want, and before they can be used with satisfaction, it is necessary to determine how to use the optional coefficients in order to obtain, at will, curves such as are wanted. The details of the formulæ and their applications are given in an appendix, concerning which it may be said that, while desirable, it is not at all necessary that one using the methods should understand the mathematics of them. In one of the illustrations, giving the body plan of a vessel with mathematical lines, each section from keel to water line is calculated mathematically by the methods explained in the appendix.

Resistance

When steam navigation entered upon the rapid development dating from the middle of the last century, it became necessary that former crude ideas as to the resistance of ships and methods of determining the power required to drive a given ship at a given speed should be replaced by ideas and methods more in consonance with facts.

In 1860, or later, we find leading authorities who considered that the whole resistance of a ship was due to surface friction and that for properly formed ships the wave resistance was negligible. All such ideas have now been discarded, and the present accepted ideas as regards resistance of ships are based entirely upon the work done by William Froude and his successors in model tank experiments. Although it is more than forty years since Froude built the first model tank in his garden at Torquay, England, and published most important results of experiments made there, it is only since a comparatively recent date—say the beginning of the present century—that model tanks and their results have been generally accepted as ordinary tools of the naval architect thoroughly to be relied upon. Here and there a sceptic may exist to-day, but the law of comparison as applied by Froude is now generally accepted.

At the United States Model Basin, during the last fifteen years, the Froude methods have been applied to the models of some 189 United States vessels, having a total displacement of about 1,163,874 tons and a value, or cost when new, of about $443,000,000 (£95,000,000). In the cases of two vessels, only, have the results of the trial of the full-sized ship differed materially from what was to be expected from the model results. This was really one case,

* From a paper presented at the International Engineering Congress, San Francisco, Cal., September, 1915.

† Chief Constructor, United States Navy.

[1] "Harmonie der Schiffsformen," by M. H. Bauer, in the "Jahrbuch der Schiffbautechnischen Gesellschaft," 1914.

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as the two vessels were sister ships. The probable cause of the discrepancy has long been known, although it acts so seldom in practice that it is apt to be forgotten.

The law of comparison, strictly speaking, requires that not only must the speed of the full-sized vessel be to the speed of the model in the ratio of the square roots of their linear dimensions, but that the pressures around the two must be in the ratio of the linear dimensions. It so happens, however, that pressure does not affect materially the resistance due to surface friction and to the formation and dispersion of waves for either model or ship. As regards the third recognized element of resistance, namely, eddying, the theoretical pressure conditions must be complied with, if the eddy resistances of model and full-sized vessel are to follow the law of comparison; but in nearly all vessels the eddy resistance is not only a small factor, but consists of eddies behind struts, stern post, etc., which are comparatively little affected by pressure. But in vessels with exceptionally full sterns, we may have eddies under the quarters, with accompanying increase of resistance; while corresponding eddies do not appear in the model, although they would appear if the pressure around the model could be reduced to scale. This was apparently the condition in the case of the two vessels above referred to, which required more power than expected to obtain their designed speed.

I would not be understood as stating that the resistance of a full-sized vessel can be determined in advance with minute accuracy by model basin experiments, or by any other method now known. As a matter of fact, the resistance of any vessel is largely due to frictional resistance. For most vessels, this factor is decidedly predominant, and we determine the frictional resistance by estimates based upon experiments made by Froude forty years ago. It is very difficult to determine with minute accuracy the actual frictional resistance of the surface of a large vessel; the workmanship, condition of plating, and other minor factors affect it appreciably, and marine growth may increase friction radically. Experiments in the United States Model Basin, with plates exposed to fouling, near Norfolk, Va., indicated that in seven months, from July to February, a marine growth by no means excessive, consisting mostly of barnacles, averaging in total weight when dry one-quarter of a pound per square foot, would increase the frictional resistance by as much as 210 percent. Moderate ordinary corrosion with no appreciable fouling will also materially increase frictional resistance.

In connection with the friction of models, it may be of interest to record that the experience of the United States Model Basin, as regards variation of friction with temperature, does not appear to be in accord with the rather discordant results obtained in Great Britain. In the early days of the establishment, in 1899-1900, Froude's frictional coefficients, deduced from experiments with varnished wooden planes were carefully checked as regards planes 20 feet long and 18 inches wide (6.1 m. x 0.457 m.). These also were varnished wooden planes, and the results were in substantial agreement with those of Froude. During the last few years, information has been published as regards the variation of resistance of models with variation of temperature in the model tank for the tank of the Messrs. Denny, at Dumbarton, Scotland, and for the William Froude tank at Kew, England. Sir Archibald Denny * stated that "the correction should be 4 percent for 10 deg. F." In the same discussion, Mr. Baker† stated "With regard to skin friction correction, Sir Archibald Denny takes 4 percent correction on the whole for a 10-degree change in temperature. We ourselves, correct 3 percent for the same range of temperature, but we only take our correction on the skin friction, because, so far as I can see, temperature cannot affect the wave resistance."

In 1912 a special investigation of this matter was undertaken at the United States Model Basin, it being planned to run a model of a battleship and a model of a torpedo boat destroyer monthly, and note temperature upon each occasion. The models used at the United States Model Basin are of wood, varnished and before a run, each model was smoothed by sandpapering and revarnished. The ordinary variation of temperature of the water in the United States Model Basin is from about 80 degrees in the height of summer to about 54 degrees in mid-winter. The temperature would fall much lower in the winter, except for the fact that the building is thoroughly heated in cold weather. In the winter of 1913, after filling the basin with fresh, cold water, the trial models were run in water as cold as 44.5 degrees. The results of these experiments were quite consistent. The only anomaly developed was when, after nine months, there had been such an accumulation of varnish that the varnish was scraped off and the models revarnished. This resulted in an anomalous reduced resistance of 3 percent. The results may be summarized as follows:

With change of water temperature there was a perceptible change in the resistance of both the battleship and destroyer models. These changes in resistance, due to temperature, were apparently more closely related to the frictional resistance than to the residuary resistance, and the percentages given below are based on the frictional resistance alone. For the battleship model, the decrease in resistance for 10 degrees F. increase in temperature was about 1.9 percent of the frictional resistance, and for the destroyer model 2.3 percent of the frictional resistance.

It is seen that this variation is much less than that apparently occurring in Great Britain. The difference may be due to one or a number of different causes. The models used in the United States Model Basin are 20 feet (6.1 m.) instead of 12 feet to 14 feet (3.66 to 4.27 m.) as usual in the British tanks; the models are wood, varnished, instead of paraffine; the average temperature in the Washington tank is materially higher than that of the British tanks; the water used, which is taken from the Washington City mains and has passed through sand filters, may be different in quality. Although the water used in filling the tank at intervals of from a few months to several years is taken direct from the Washington City mains, the small stream kept constantly running in is refiltered with a small amount of alum injected prior to refiltering.

It has been the endeavor of many people in the past to devise a formula expressing the resistance of a ship. The numerous results of the model-basin experiments which have been published in the last ten or fifteen years have been rather discouraging to the development of any such formula.

We have learned that a factor which is of importance at one speed is almost negligible at another. If we take two vessels, identical in dimensions and displacement, and build one with fine ends and the other with full ends, the fine-ended vessel will offer much less resistance over a certain range of speed, while at extreme speeds the full-ended vessel will be materially better.

Some years ago there were published the results of experiments with a large number of models at the U. S. Model Basin,* where proportions and coefficients had been varied systematically. The general results of this so-called standard series agree very closely with the general results from a very large number of additional models of

* Page 63, Transactions of the Institution of Naval Architects, 1914.
† Page 64, Transactions of the Institution of Naval Architects, 1914.

* "The Speed and Power of Ships," D. W. Taylor, 1910.

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usual types tried at the U. S. Model Basin, and also agree very well with exceptional results from other model basins. If a formula or formulæ could be devised which would accurately express the plotted results of the standard series referred to, we should have the desideratum of many years. Attempts to do this have not been very successful, but the results, as plotted, show the broad features of the resistance of ships of usual types.

In the first place, the actual size of a vessel, its displacement, is, of course, the primary factor in its resistance. In the second place, the proportions come into play. Viewing this aspect of the case, the most important feature is the length used for a given displacement. Beam and draft are comparatively minor factors, while the length is a major factor. Length is of peculiar value for cutting down the wave-making resistance; hence, we find that for fast vessels, where wave-making resistance is of such importance, the total resistance may nearly always be decreased by increasing the length. The third factor of primary importance is the longitudinal or prismatic coefficient, or what is in a way the same thing, the nature of the ends, whether fine or full. This is a very important factor. For speeds which are moderate in proportion to the length of the vessel—that is, when the speed-length ratio, or speed of vessel in knots divided by the square root of the length in feet is below about 0.8 (0.442 in metric units)—the large midship section and fine ends are nearly always favorable to speed. About a speed-length ratio of 0.95 (0.525), there is a somewhat indeterminate region where variation of the longitudinal coefficient does not produce much effect. For high speeds, however, say of speed-length ratio above 1.25 (0.695), we gain, by reducing the midship section and using large longitudinal coefficients, even up to 66 percent, and their associated full ends.

There appears no question that the fore body has much greater influence upon resistance than the after body. Experiments, described in the Transactions of the Society of Naval Architects,* show that radical variations in the shape of sections of the after body produced comparatively little effect upon resistance. The shape of the sections forward, however, does materially affect the resistance, and for the great majority of vessels there is no doubt that fine or hollow lines forward near the surface of the water, resulting in forward sections full below water, even bottle-shaped in many cases, are favorable to speed. Many sea-going people and naval architects are opposed to hollow water-lines forward, but there are indications that the results of model-tank experiments are making more and more impression upon practical people; and although we may not again find in fashion the very hollow lines of Scott Russell, we are certainly much nearer to this extreme than we were ten years ago.

Sir Archibald Denny, in his presidential address this year at the Institute of Marine Engineers, pointed out that of late years there has been a decided reduction in the block coefficients of low-speed cargo vessels, due to unsatisfactory experience at sea with those of coefficients of 0.80 or over. It would not have been necessary to settle this question by trial and error on full-sized ships at sea, if careful investigations of models had been carried out. There have now been published sufficient results of systematic model investigations† to enable the competent naval architect, dealing with merchant vessels, to settle with quite satisfactory accuracy the relative financial results to be expected in service from vessels of varying form and fullness of usual types. For special and unusual types and for vessels for high speed in shoal water, it is necessary to go largely by guesswork or to have recourse to model experiments, which will be found, by far, the most profitable capital investment in such cases.

(To be continued.)

* "Some Experiments with Models having Radical Variations of After Sections," D. W. Taylor, Transactions of Society of Naval Architects and Marine Engineers, 1914.

† "Some Results of Model Experiments," R. E. Froude, Transactions of the Institution of Naval Architects, 1904. "The Speed and Power of Ships," by D. W. Taylor, 1910. "Model Experiments on the Resistance of Mercantile Ship's Forms," G. S. Baker, Transactions of the Institution of Naval Architects, 1914.

International Engineering Congress

The most important meeting of engineers that has taken place in this country for many years is the International Engineering Congress, which was opened in San Francisco on September 20 and continued for six days. The following papers were presented before the section devoted to naval architecture and marine engineering:

TUESDAY, SEPTEMBER 21

"Ship Calculation, Resistance and Propulsion." By Rear Admiral D. W. Taylor, U. S. N., chief constructor, United States Navy.

"Ocean Freighters." By Ernest H. Rigg, naval architect, New York Shipbuilding Company, Camden, N. J.

"Recent Developments in Japanese Shipbuilding." By Dr. E. Terano, professor of naval architecture, Tokyo Imperial University, Tokyo, Japan.

"Bulk Freight Vessels of the Great Lakes." By Professor Herbert C. Sadler, professor of naval architecture, University of Michigan, Ann Arbor, Mich.

AFTERNOON SESSION

"River, Lake, Bay and Sound Steamers of the United States." By Andrew Fletcher, president, W. & A. Fletcher Company, Hoboken, N. J.

"Special Types of Cargo Steamers for the United States Coast to Coast Trade Through the Panama Canal." By George W. Dickie, naval architect, San Francisco, Cal.

"The Development of the Sail Yacht, Steam Yacht and Motor Yacht in American Waters." By William Gardner, naval architect, New York.

"The Lightship." By G. C. Cook, Department of Commerce, Lighthouse Service, Washington, D. C.

WEDNESDAY, SEPTEMBER 22

"Warships of the First Line of Battle." By Col. E. Ferretti, chief constructor, Royal Naval Arsenal, Naples, Italy.

"The Submarine." By R. G. M. Robinson, managing director, Lake Torpedo Boat Company, Bridgeport, Conn.

"Present Conditions of the Submarine." By Max A. Lauberf, late chief constructor, French Navy, Paris, France.

"Modern Marine Gun Armament." By Lieut. H. F. Leary, U. S. N.

"General Problem of Naval Warfare." By Lieutenant-Commander D. W. Knox, U. S. N.

THURSDAY, SEPTEMBER 23

"Marine Boilers and Boiler Room Equipment." By Charles F. Bailey, chief engineer, Newport News Shipbuilding & Dry Dock Company, Newport News, Va.

"The Development of the Marine Steam Turbine." By Lieutenant-Commander H. C. Dinger, U. S. N.

"The Application of the Steam Turbine to Marine Propulsion." By J. F. Metten, chief engineer, William Cramp & Sons Ship & Engine Building Company, Philadelphia, Pa.

"Recent Development in Marine Engineering in Japan." By Dr. M. Tsutsumi, chief engineer surveyor, Japanese Mercantile Marine Bureau, Tokyo, Japan.

"Coaling Plants and Floating Cranes of the Panama Canal." By F. H. Cooke, civil engineer, U. S. N.

"Cargo Handling Methods and Appliances." By H. McL. Harding, consulting engineer, New York.

"Some Economic Fundamentals of Freight Handling." By David B. Rushmore, chief engineer, power and mining department, General Electric Company, Schenectady, N. Y.

"The Modern Trend in American Marine Terminals." By Robert H. Rogers, power and mining engineering department, General Electric Company, Schenectady, N. Y.

"Cargo Handling Methods and Appliances." By James A. Jackson, power and mining engineering department, General Electric Company, Schenectady, N. Y.

FRIDAY, SEPTEMBER 24

"Fuel Oil." By E. H. Peabody, chief engineer, marine department, Babcock & Wilcox Company, New York.

"The Application of Diesel or Heavy Oil Engines to Marine Propulsion." By G. C. Davison, vice-president, Electric Boat Company, Groton, Conn.

"The Diesel Motor Applied to Marine Purposes." By C. Kloos, technical director, Werkspoor, Amsterdam, The Netherlands.

AFTERNOON SESSION

"Terminal Works, Dry Docks and Wharves of the Panama Canal." By H. H. Rousseau, civil engineer, U. S. N.

"Aids to Navigation of the Panama Canal." By W. F. Beyer, Milwaukee, Wis.

"American Graving Dock Practice." By Leonard M. Cox, civil engineer, U. S. N.

"Dry Docks Recently Built in Italy." By Professor Luigi Luiggi, Dr. of Sc., Rome, Italy.

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Design of Small Screw Propellers*

Size and Location—Safe Peripheral Speed—Preparation of Actual Working Drawings

BY D. H. JACKSON

This paper deals with the subject of small screw propellers, purely as it affects the draftsman or designer. The author has not touched upon any of the classic experiments and the more or less abstruse theories deduced from them, but has endeavored to treat the matter throughout from a fairly practical standpoint, as covered by his own experience. So far as the draftsman is concerned, the first question to engage his mind on the subject of a propeller is:

(*a*) How much room will the propeller occupy? If the diameter be proportioned on past experience, will the consequent shaft-line be convenient and practicable? This consideration is often of great importance when dealing with small propellers.

(*b*) Will the peripheral speed of the propeller be within safe limits?

These two points have usually to be settled in short time and at short notice. Often, indeed, the diameter and pitch of propellers, and the exact position of shaft-line, have to be fixed at the time of tendering for an order, which is usually a very strenuous period.

This task being safely completed, the unfortunate and long-suffering draftsman is granted a breathing space until the time arrives for:

(*c*) The preparation of actual working drawings of the propeller.

There are pitfalls awaiting the unwary, even in this process. They are, however, not usually of a serious nature, and the author is bold enough to hope that certain of the notes contained in this paper may help to smooth the way of the draftsman over some of these points.

Now let us revert to the first consideration:

How Much Room Will a Propeller Take?

Probably the great stand-by of the draftsman in the matter is one or other of the well-known formulæ:

(1) Diameter of propeller is proportional to

$$\sqrt[3]{\frac{I.H.P.}{R}}, \text{ or else}$$

(2) Diameter of propeller is proportional to

$$\sqrt[2]{\frac{I.H.P.}{S_3}}$$

Where I. H. P. = indicated horsepower transmitted through *one* propeller.

R = revolutions per minute. S = speed of vessel, in knots.

Now, in spite of the careful experiments, deductions, etc., on which these two formulæ are based, the author is of the opinion that equally close results, together with greater handiness of calculation, may be obtained with the formula:

(3) Diameter of propeller is proportional to

$$\sqrt[2]{\frac{I.H.P.}{S}}$$

Obviously, such a formula only holds good for cases of close similarity, in form of vessel and speed. The Tables I and II annexed give some characteristic comparisons derived from the use of formula (3). Table I shows a number of examples of small vessels of full body; displacements varying from 100 to 500 tons; speeds up to about 14 knots. Table II shows a number of examples of vessels of from 700 to 1,000 tons displacement, and of high speed. Needless to say, where shaft horsepower and indicated horsepower are to be compared, the value of I. H. P. must be multiplied by a suitable coefficient (generally about 0.9) to obtain the corresponding S. H. P. For ships fitted with Diesel engines, this coefficient should be diminished to about 0.8 to 0.85.

TABLE I

No.	I.H.P. through one Propeller	Speed in Knots	$\sqrt{\frac{I.H.P.}{S}}$	Dia. of Propeller	Dia. of Propeller / $\sqrt{\frac{I.H.P.}{S}}$
1	600	14	6.54	4.67 feet	0.71
2	400	10	6.33	4.75 "	0.75
3	600	10	7.75	6.00 "	0.775
4	600	10	7.75	5.90 "	0.76
5	800	14	7.56	6.00 "	0.795

In connection with Table I it may be noted the propeller in example No. 1, ran at about 200 revolutions per minute, while that in No. 5 example ran at about 350 revolutions per minute.

TABLE II

No.	S.H.P. through one Propeller	Speed in Knots	$\sqrt{\frac{S.H.P.}{S}}$	Dia. of Propeller	Dia. of Propeller / $\sqrt{\frac{S.H.P.}{S}}$
1	2,200	27	9.02	4.00 feet	0.443
2	4,960	28.2	13.3	5.54 "	0.417
3	8,250	30.6	16.4	6.75 "	0.41
4	12,250	32	19.6	7.67 "	0.39
5	8,570	33	16.2	7.00 "	0.432

It will be noticed that example No. 4 in Table II shows a considerable discrepancy in the value of

$$\frac{\text{diameter of propeller}}{\left(\sqrt{\frac{S.H.P.}{S}}\right)}$$

That particular ship was of a bad form for the high speed at which she was driven. The propellers described in Table II were all driven by steam turbines at, say, 600-650 revolutions per minute.

The above two tables will naturally suggest the construction of a curve in which the values of

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$$\frac{\text{diameter of propeller}}{\left(\sqrt{\frac{S.H.P.}{S}}\right)}$$

are plotted against corresponding values of the block coefficients of displacement of the ships under consideration. Such a curve may readily be drawn by any draftsman to suit the class of work with which he may be dealing. For obvious reasons the author is not at liberty to publish such a curve drawn from his own experience. It must be

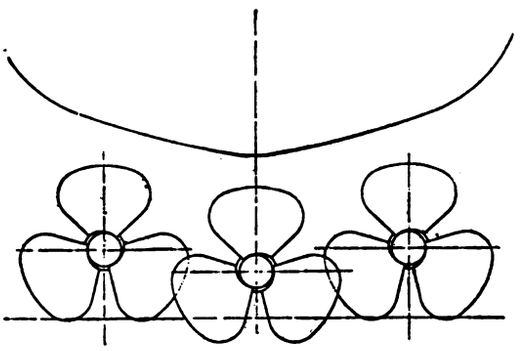

Fig. 1

borne in mind, however, that with vessels of high speed, results calculated in this way upon the block coefficient of displacement may be seriously upset by a bad design of hull, particularly where the after-body is of unsuitable form, as exemplified in Table II, No. 4.

Tip Clearance

The question of diameter being settled, the next point, perhaps, is that of tip clearance. This must, without doubt, be greatly influenced by the peripheral speed at which the propeller is to run. For propellers running at

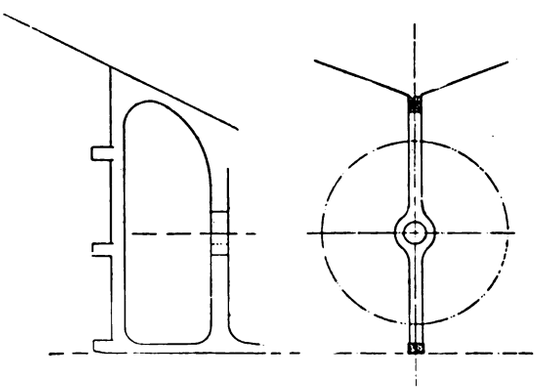

Fig. 2

very high speeds, such as those fitted in turbine-driven vessels, it appears that the clearance between the propeller circle and the ship's skin should not be less than about 18 inches; which figure might, when absolutely necessary, be reduced to 16 inches, although many designers stand out for not less than 24 inches of tip clearance for propellers of this class. The writer has in mind a vessel having tip clearance, between the propeller circle and the ship's skin of 18 inches, with the propellers running at a peripheral speed of about 15,000 feet per minute. These particular propellers proved themselves remarkably efficient in every way, in spite of the high peripheral speed and relatively small clearance. There is no doubt that with turbine-driven vessels having three or four screws a great loss of efficiency is caused by overlapping of the propeller circles, as shown in Fig. 1. This fault should be carefully avoided by the designer as far as possible.

Turning now to propellers running at slower speeds, it is evident that the tip clearance may be greatly reduced. Probably the figure may be very much smaller where the point of minimum clearance occurs against the skin of the ship than where the propeller revolves in the ordinary type of stern frame, as illustrated in Fig. 2. This amounts to saying that twin screws may have smaller clearance than single screws. The same point is borne out by usual

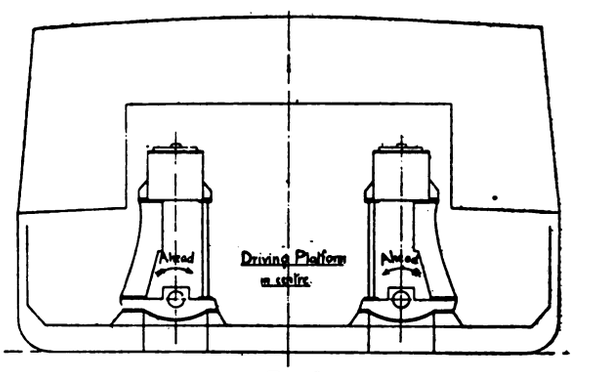

Fig. 3

practice in the construction of raised propeller steamers (in which, to secure a shallow draft, the propeller works in a tunnel formed in the stern of the vessel). In many such steamers the tip clearance has not exceeded 1½ inches, with peripheral speeds of some 3,000 feet per minute. In connection with vessels of this class it is worth noticing that there appears to be no loss of efficiency caused by the propellers of twin screw steamers turning inward, while the consequent improved accessibility of the engines (see Fig. 3) is undoubtedly a great advantage.

Pitch

On the subject of pitch of propellers little need be said; most designers have ample data concerning slip upon which to base their calculations. Here it might be noted that the mistake is occasionally made of using a formula:

$$\text{Pitch} = \frac{\text{speed in knots} \times 101.3 \times (100 + \text{percentage of slip})}{\text{revolutions per minute} \times 100}$$

This should, of course be written:

$$(4)\quad \text{Pitch} = \frac{\text{speed in knots} \times 101.3 \times 100}{\text{revs. per min.} \times (100 - \text{percentage of slip})}$$

The use of the wrong formula has the effect of reducing the result obtained, thereby probably making for an inefficient propeller. Some few engineers, in spite of the experimental research of the standard authorities on propellers, with the obvious deductions therefrom, are inclined to design propellers for very small slip; it seems to be well borne out that for small vessels of fairly fine form and of speeds ranging from 10-12 knots upward, slips may be as high as 20 percent, or even in some cases 25 percent, without necessarily indicating a lack of efficiency. It is certainly desirable that the ratio of pitch to diameter should be kept fairly high, which naturally involves increased slip, if the engines are to run at their full designed speed.

The preliminary figures of diameter and pitch having been settled, there remains:

The Preparation of Working Drawings

Here the question of blade area becomes important. Now the blade areas of propellers for similar conditions

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may be compared by means of a formula analogous to that (No. 3) dealing with diameter of propeller circle as follows:

(5) Blade area is proportional to $\sqrt{\frac{H.P.}{S}}$.

In the writer's opinion the most desirable figure to compare in this way is what is known as the projected area of the blades. Another useful means of calculating the blade area required depends upon the thrust per unit surface of projected blade area. This figure may be as high as 12-14 pounds per square inch for vessels of high speed

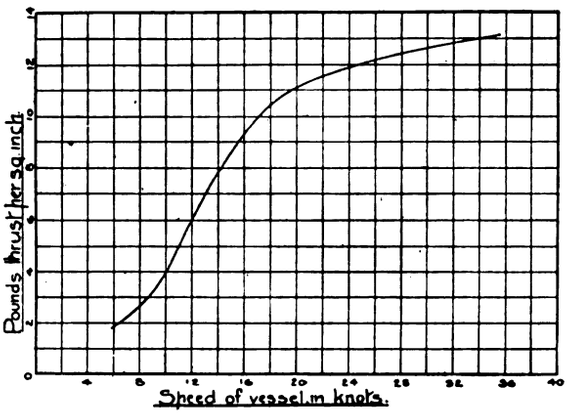

Fig. 4

(say 25 knots and upward); while for quite small vessels (say 60 feet length or thereabout) of moderate speeds, the corresponding figure comes down to about three pounds per square inch. The curve (Fig. 4) in which thrust per square inch is plotted against the speed of the vessel, may serve to give some idea of the figures allowable.

Scantlings of Boss and Blades

The next point to be considered is the axial length of the propeller boss. This often has to be settled before the actual working drawings of the propeller are prepared, because of its relation to the design of the tail-end shaft. It must be noted, in connection with the following remarks, that the common practice with propellers of the size herein discussed—up to six or seven feet diameter—is to cast the blades solid with the boss. For propellers of normal form, such as would be fitted to vessels of moderate speed, the axial length of boss will be from one-eighth to one-sixth of the diameter of the propeller. The diameter of boss bears a close relationship to the thickness at root of blades, and must be considered in connection therewith. These two points will be dealt with later. The taper of the coned bore of propeller to suit the tail-end shaft is commonly made 1 inch diameter in 10-inch length. A finer taper, viz., 1 inch diameter in 12-inch length, is often used; there seems, however, to be no great advantage to be gained by this fine taper, while the difficulty of withdrawing the propeller is certainly increased, giving rise to the use of much bad language, for which the designer is, in part at least, responsible.

For obtaining the thickness at root of blades a number of formulæ are in common use:

(6) $T = \frac{1}{2}$ inch per foot of diameter for cast iron, $\frac{3}{8}$ inch for gun metal, 5/16 inch for cast steel or bronze.

(7) $T_1 = \sqrt{\frac{d^3}{n \times b}} \times K + C$. (Seaton.)

(8) $T^3 = \frac{N \times I.H.P. \times (D - d_1)}{B_1} \left(\frac{d_1}{P \times S} + \frac{20}{R.D.} \right)$ (Barnaby)

Probably the most reliable formula for all cases is the Admiralty formula:

(9) $M = \frac{B \times T^2 \times R \times P}{I.H.P. \times (D - d_1)}$

T = thickness of blade at surface of boss, in inches. T_1 = thickness of blade at center of shaft, in inches; see Fig. 5 (a). d = diameter of tail-end shaft, in inches. d_1 = diameter of boss, in inches. D = diameter of propeller, in feet. n = number of blades in one propeller. b = breadth of blade at root, in inches, measured parallel to shaft (see Fig. 5 (b)). B = breadth of blade at root, in inches, measured as in Fig. 5 (c). B_1 = breadth of blade at root, in inches, measured as in Fig. 5 (d). R = revolutions per minute. P = pitch of propeller, in feet. $I.H.P.$ = indicated horsepower transmitted *through one blade*. S = speed of vessel in knots. $C = \frac{1}{4}$ inch, $K =$ 1.5, $N = 2.0$ (all of manganese bronze).

Now M, the constant in the Admiralty formula, has for an ordinary manganeze-bronze propeller a value of from 90 to 120, according to circumstances, with proportional values for cast iron or cast steel. A propeller was recently designed to work in rough, broken water, where whirlpools, rapids, small branches of trees and other unpleasant incidents were commonly to be met with. For this purpose the constant M for a propeller 6 feet diameter, 6 feet 6 inches pitch, of manganese bronze, was made equal to

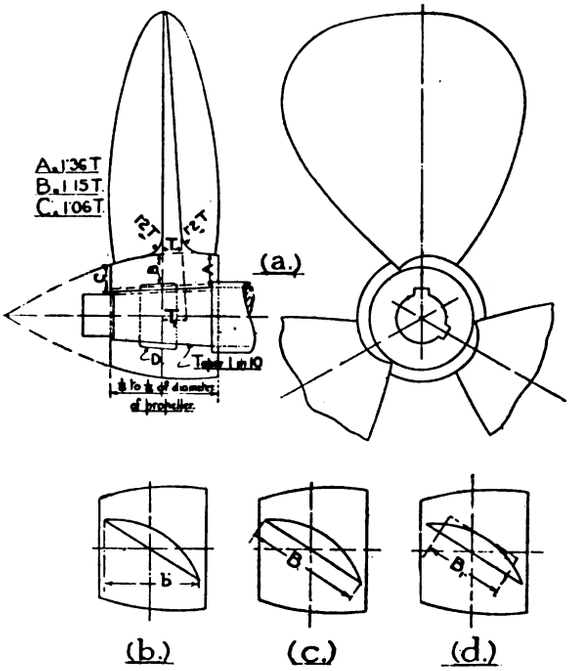

Fig. 5

130. This propeller has given satisfaction in service, and up to the present still has its full complement of blades.

In order that a sound casting may be obtained, it is of the utmost importance that the thickness of metal at the boss should be carefully proportioned to suit that at the root of the blade. Fig. 5 (a) shows proportions which give good results. The thickness of metal in the boss should not be less than that shown, but may be more if desired. A should, however, be greater than B, and B should be greater than C. The founders generally prefer, especially in bronze propellers, that the propeller should be cast without the recess indicated at D, this recess being afterwards machined out when the propeller is bored. Such preference may possibly be due to the practice of

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charging for castings by weight. In any case, the axial length of the recess should not exceed about one-third of the length of the boss. Two keys must be fitted, and it is an advantage to arrange each keyway in the propeller to

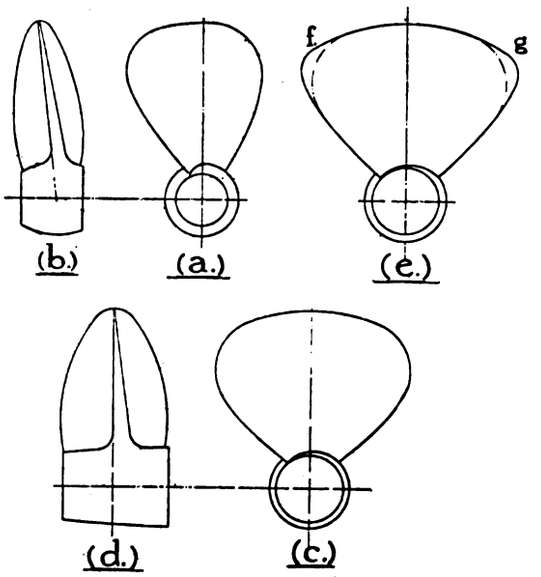

Fig. 6

come opposite to the root of a blade. Hence a four-bladed propeller will have two keys placed 90 degrees apart, while those in a three-bladed propeller will be arranged 120 degrees apart. See also Fig. 5. It may be noted that the crushing load on the side of the keys has been allowed as follows, with satisfactory results:

Crushing load on side of key in shaft, 22,000 pounds per square inch. Crushing load on side of key in propeller, 18,000 pounds per square inch.	Assuming one key to transmit 2/3 of total torque.

These are, however, high values, and must certainly not be exceeded. The thickness at the tip of the blades of an ordinary manganese-bronze propeller need not exceed ⅜ inch for a propeller 6 feet in diameter, while for a high-speed propeller of that size, with good tip clearance, it may be ¼ inch with perfect safety.

Shape of Blade

Much has been written, many ingenious theories have been advanced, and many equally ingenious designs have been registered and patented, all dealing with the shape of propeller blades. And, speaking very broadly, not one of these ingenious designs is any better than its fellows, and not one shows any real superiority over the simple blade form which is commonly adopted. General experience and practice lead one to the conclusion that for propellers of moderate speed, the type of blade form shown in Fig. 6 at (a) gives good results. It is probably also an advantage for the blade to be set back as shown at (b), instead of normal to the shaft centerline, as indicated in Fig. 6 at (c) and (d). In propellers of the latter class, where very wide blades are common, it is well to avoid blades of the form shown at (e) in Fig. 6. Such a blade form does not give good results, probably because the mechanical weakness of the corners of the blade indicated at (f) and (g) causes deformation of the blade under working conditions. A propeller having blades of that form might possibly be improved by the removal of these corners, in spite of the reduction of area entailed.

Projection of Propeller Blades

With regard to the actual projection of propeller blades, the following method was evolved by the writer for his own use. It differs from most methods commonly em-

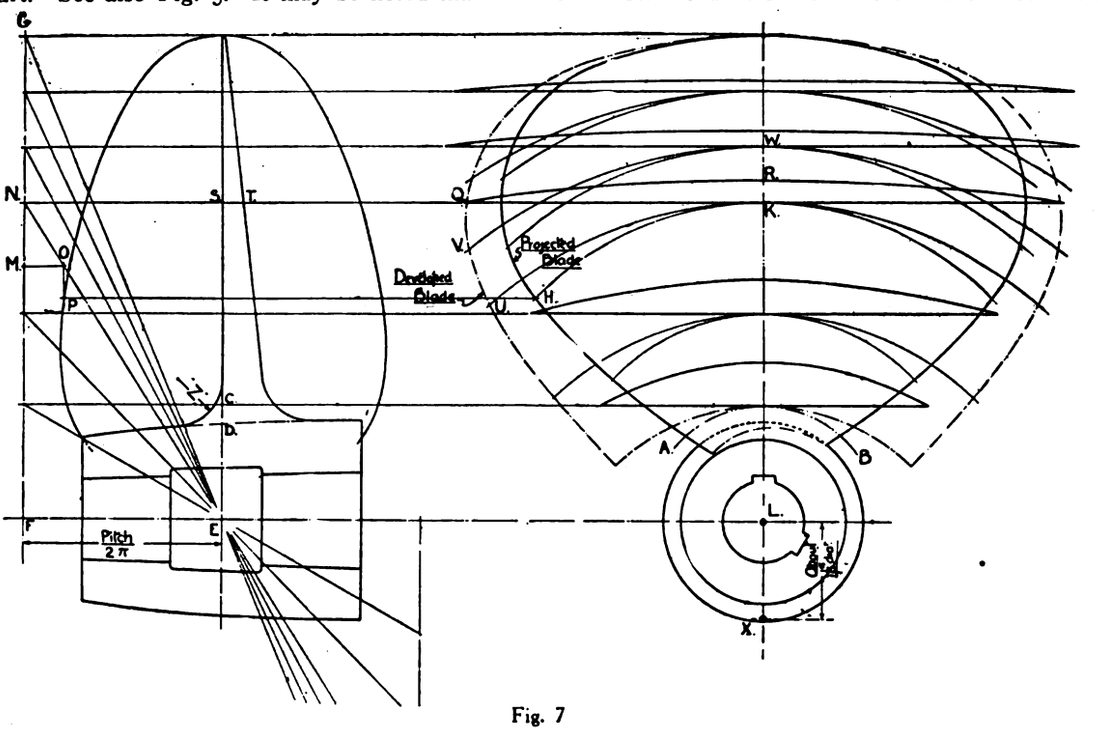

Fig. 7

ployed in that it gives an absolutely correct projection of the propeller, and also gives a correct value for the developed area. Especially with the very wide forms of blade common in propellers for turbine-driven vessels of high speed, the inaccuracies involved with the usual methods of projection are sometimes of some consequence.

Referring to Fig. 7, the section of boss and blade is drawn from figures obtained in the manner previously

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described under the heading "Scantlings of Boss and Blades." The projected blade is next drawn to give the required area and blade form. The projected area should be reckoned on that part of the blade outside the circle *AB*, the distance *CD* being made equal to one-third of the radius *Z*. The line *FG* is drawn parallel to the working surface of the blade, in the usual manner, the distance *EF* being equal to

$$\frac{\text{Pitch of propeller}}{2\pi}$$

The length of arc *HK* (which is drawn about the center of propeller *L*) is measured along the line *FG*, from *F*, giving the point *M*. This is readily done by means of a flexible steel scale, a flexible batten, or other similar means. The point *M* is projected back on to the pitch line *NE*, corresponding to the arc *HK*, giving the point *O*. The point *O* is projected perpendicular to *EF*, to meet the projector drawn from *H*, parallel to *EF* in the point *P*. Then *P* is the side elevation of the point *H* at the edge of the propeller blade. The length *OE* is the actual length of the helical arc, *HK*, on the surface of the blade. Transferred to *KQ*, this length gives a half developed section of the blade, at the radius *LK*, *KR* being equal to *ST*. A circular arc, *KU*, is drawn about the center *X*, the distance *LX* being equal to about one-tenth of the diameter of the propeller. This same point *X* is the center of all corresponding arcs—e. g., *WV*. Now if the straight-line length, *OE*, be transferred to the circular arc *KU*, measuring from *K* to *U*, then *U* is the corresponding point to *H* on the developed or expanded blade. This process being repeated, the side elevation and developed view of the blade are obtained as shown. The side elevation is a correct projection of the blade, and the development of the blade gives the correct developed area, together with a good approximation to the shape. It is, of course, impossible correctly to develop the shape of a propeller blade on to a flat surface. The foregoing method of projection may readily be adapted to deal with propellers having either set-back blades or blades of increasing pitch. The methods of adaptation will be obvious to anyone accustomed to the design of propellers.

The writer makes bold to hope that these notes on propeller design may have touched upon some points which are not as a rule made clear in text-books, but which are of real interest to the propeller-draftsman. In conclusion, the writer's thanks are due to Mr. H. E. Yarrow for permission to publish certain of the foregoing notes.

Modern Submarines in War and Peace—IV

Motive Power of Submarines for Surface Work—The Heavy Oil Diesel Type Engine—Periscopes

BY SIMON LAKE

The internal combustion engine is the "heart" of the submarine. It is the only motive power thus far evolved suitable for submarine use. When properly designed and built, it will be "ideal" for the service.

The internal combustion engine has the advantage over any other known "prime motor," in that it can be started or shut down instantly. This is of the first importance, as it permits of quick submergence or emergence, either to "submerge" and escape from a high-speed surface destroyer, or to "emerge" and capture a merchantman. It also permits of comparatively high speeds and larger radius of action submerged, when installed in a manner I shall indicate later in connection with "high speed submarines." It weighs less per horsepower, takes up less space, and requires less fuel per hour than any other reliable prime motor, unless something radically new is evolved. The internal combustion engine is therefore bound to survive as the prime motive power for submarines.

The Argonaut's Engine

The writer was the first to use an internal combustion in a submarine boat (in the *Argonaut*). This first engine was a heavy duty engine of rugged construction, and gave but little trouble. It weighed over 75 pounds per horsepower. This type of engine, with but slight modifications, was installed in six other boats built subsequent to the *Argonaut*. They also worked satisfactorily for several years, and as long as I had knowledge of them (they were sold abroad) they always gave satisfactory and reliable service.

The first gasoline (petrol) internal combustion engines installed in the Holland boats were also of rugged construction, and the writer has been informed by various officers in our submarine service that they are reliable and gave but little trouble. It is known that, after twelve years' service, some of them are still doing good work. The boats in which these engines were installed were slow speed boats, making only from eight to nine knots on the surface. A natural desire on the part of the Government was to secure increased speed. They sent out requirements to submarine boat builders calling for increased speeds within certain limits of cost.

The submarine boat builders said: "Certainly, we can give you increased speed, if the engine builders can give us engines of the necessary power to go into the available space, and within a certain weight to thus enable us to get the power plant within a certain size vessel possessing the fine lines to give the required speed within the limit of the appropriations." The engine builders said *they could do it.*

The first, as I remember, to break away from the slow speed, heavy duty type was a celebrated Italian firm. Then two large and well-known German firms followed, then a celebrated English firm, and certain American firms claimed they could build reliable, compact, high speed engines on very much less weight than we had been using. I remember one American firm offered engines as low as 20 pounds per horsepower. Fortunately, we had sense enough to refuse to accept an engine so light as that, but we, as well as all other submarine boat builders, both in this country and abroad, did accept contracts which required engines very much less in weight than the old, slow, heavy duty type first used, and there has been "wailing and gnashing of teeth," both by the submarine boat builders and by the engine room forces, in the world's submarine navies ever since.

The first light weight engines built by the Italian firm

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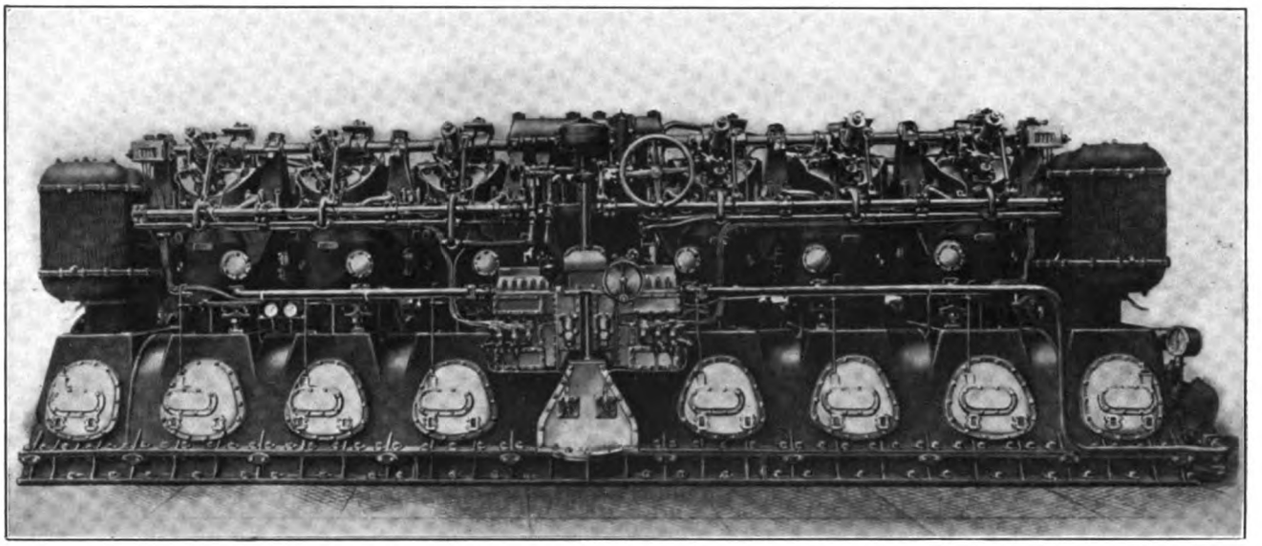

Fig. 33.—Latest Model of Krupp, Six-Cylinder, Two-Cycle, Diesel Engine

Scavenging cylinders are arranged at each end, high-pressure pumps for injecting fuel and for starting and maneuvering purposes, as well as the control gear, is located at the center of the engine. Just previous to the war the Krupps had a large number of these engines under construction.

"smashed up" in short order. The German engines followed suit, and the losses to this firm, or to the shipbuilders, must have been enormous, as a large number of engines were built by them before a set was tested out in actual service. The test of an engine in the shop, on a heavy foundation, open to inspection on all sides, and with expert mechanics in constant "touch" with the engine, does not mean that this same engine will prove satisfactory in the restricted space available in a submarine boat when run by other than expert engine-building mechanics.

I was present at a shop test of one of the German engines referred to, and under shop conditions it appeared to work very well, so well, in fact, that I took an option for my firm to build from the same designs in America. When the engine was tried out, however, in one of the German submarines, it rapidly deteriorated and, figuratively speaking, smashed itself into "junk" in a few weeks. Cylinders and cylinder heads cracked, bed plates were broken and crankshafts twisted or broken. It was evident that the design was too light all the way through.

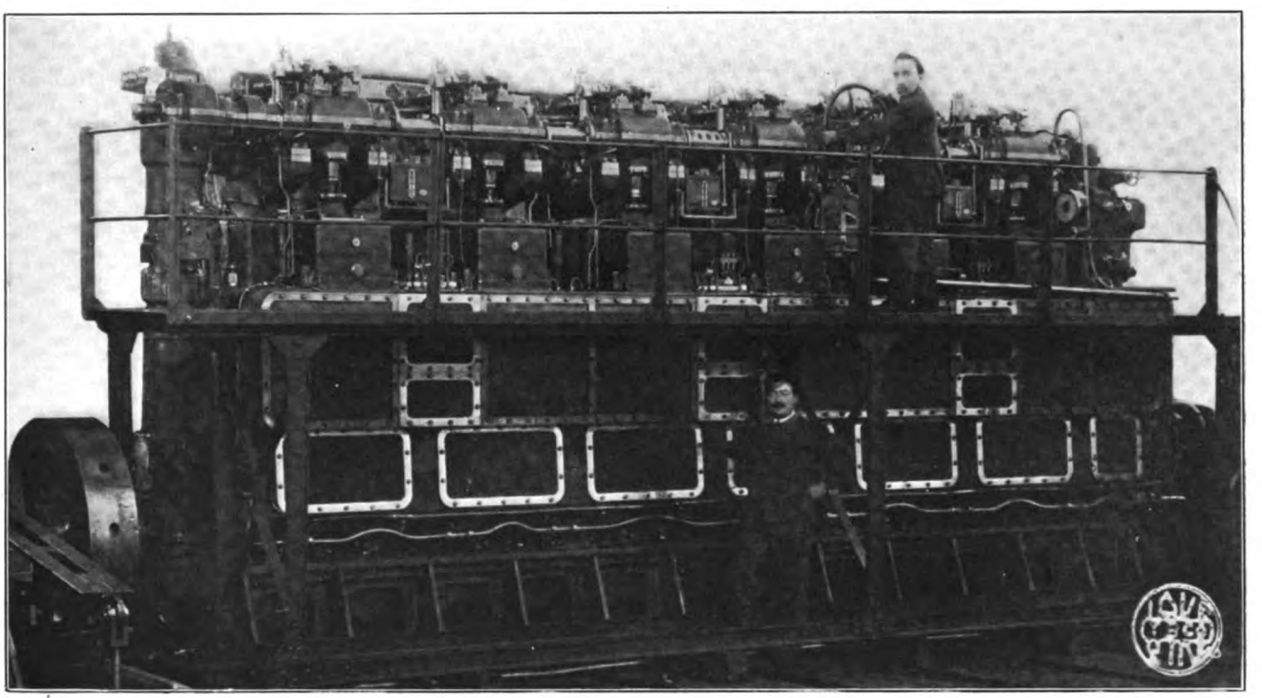

Fig. 34.—Fiat—San Giorgo, Six-Cylinder, Two-Cycle, Diesel Submarine Engine, Designed to Develop 1,300 Brake Horsepower at 350 Revolutions per Minute

This is the largest submarine engine that has so far been built, of which the author has any knowledge. It was built for one of the German submarines, and was tested out and had successful shop tests of twenty-four hours' duration at full power, and six days' and six nights' continuous run at four-fifths full power, just previous to the beginning of the present war. No information is at present available as to its operation in actual service on board the vessel for which it was designed.

Our Congress last year made an appropriation for fleet submarines calling for a surface speed of 25 knots. To secure 25 knots will require vessels of probably not less than 300 feet in length, with probably not less than 10,000 horsepower. It will be seen, therefore, that much has yet to be done in the way of development of high-powered engines suitable for submarine vessels of such high speed as 25 knots. There is no difficulty in the way of designing and building a vessel for 25 knots as soon as suitable engines are developed for them.

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There are some destructive actions in connection with large, high speed, light weight internal combustion engines that practically all designing engineers have failed to grasp. Otherwise, engineers of all nationalities would not have failed to the extent they have, and I do not believe there is a submarine engine in service to-day that has fully met the expectations of its designers and builders.

It is unfortunate for the engineering profession that government policy will not permit of a full disclosure of the defects of engines and other equipment in government-owned vessels. Were a frank disclosure made, other inventors and engineers would, in all probability, take up the problems, and they might the sooner be solved.

All the earlier submarines were equipped with engines which used gasoline (petrol) as a fuel, but the gas from this fuel when mixed with a proper proportion of air, is

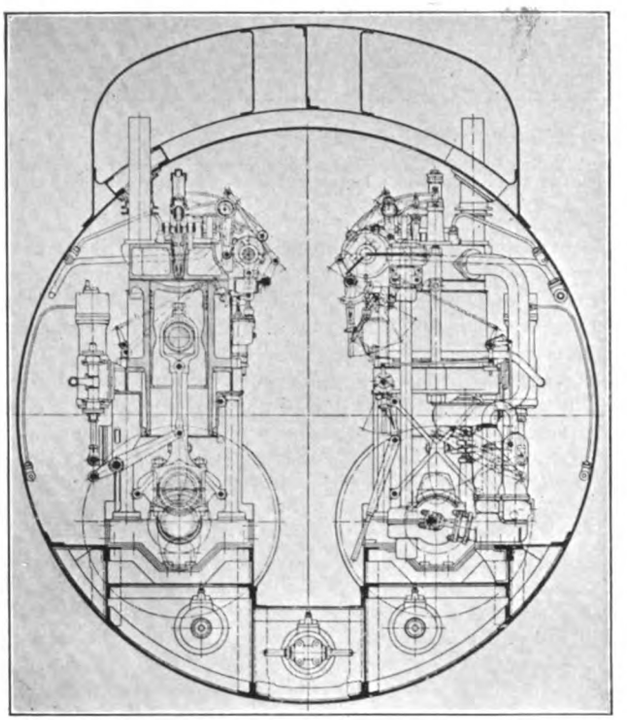

Fig. 35.—End Elevation and Sectional View Through a 200-Horsepower, Four-Cylinder, Four-Cycle Submarine Engine of Krupp Design, Installed in a Submarine Boat

This view is typical of submarine engine installations in submarine boats. Owing to the call for increased speeds, it will be observed that the engines leave very little room for the operators to pass either between or behind them. In many installations it is impossible to pass between the engine and the skin of the ship. It is therefore essential in the designing of a submarine engine that all parts of the engine be readily accessible from the front. The inaccessibility of parts is even more pronounced than is indicated in the above illustration, as the lubricating piping, water circulating piping and many of the minor parts of the engine are not indicated in this illustration.

highly explosive. A number of serious explosions occurred in submarines due to this gas escaping from leaky tanks, pipings or valves. Some of them were accompanied by loss of life. The most disastrous was that on board the Italian submarine *Foca*, in which, it is reported, twenty-three men were killed. Therefore, several years ago, all governments demanded the installation of engines using a non-explosive fuel. All builders then turned to the "Diesel" engine as offering a solution of the problem.

As early as 1905 I had anticipated that such a demand would ultimately be made, so during that year I built (in Berlin, Germany) an experimental double-acting heavy oil engine, but unfortunately the engineer in charge of the work was taken ill and eventually died. This engine was later completed and showed great flexibility in its control and in reversing. It, however, has never been put on a manufacturing basis.

First Diesel Engine for Submarines

In the meantime, others took up the work of developing the heavy oil Diesel engine for submarines. The first of the Diesel type engines to be installed in a submarine were built by a well-known French firm of engine builders. As we were then in the market for heavy oil submarine engines, plans of these engines were submitted to me, but I found it impossible to install them in any boat we then had under construction owing to their size and weight. I have been advised that engines of this design were installed in some of the French submarine boats, and I have also been informed that the shock and vibrations produced by them were such as to cause the rivets in the boats to loosen and start the vessel leaking so that it was found necessary to take them out. These engines differed only slightly from the vertical Diesel land engine. They were of comparatively slow speed, with very heavy flywheels and of the four-cycle type.

The Diesel engine builders then turned their attention to higher speed engines, and several firms brought out engines, both four and two cycle, running at speeds of from 400 to as much as 550 revolutions per minute, with piston speeds of as much as 1,100 feet per minute. Before these engines were built and tested out in actual service, governments began to demand that they be made reversible. This brought about still further complications. Reference to the top of the cylinder heads of one of the best known and most successful of the "Continental" engines, shown on page 453, will give some idea of the complication brought about by this demand for reversibility.

Complicated Mechanism on Cylinder Heads

The engine as shown contains no less than 12 cams per cylinder, a multiplicity of rocking levers, valves, etc., which make the head exceedingly complicated. Another six-cylinder American reversible engine of recent design which contains 4 cam shafts, 78 cams, with their multiplicity of cam wheels, levers, valves, etc., is, if anything, more complicated than the foreign design shown. The writer witnessed the tests of one of these reversible "Continental" engines in a small boat in Europe and in the engine room it sounded as if "pandemonium" had broken loose. This was a high speed engine running at about 450 revolutions per minute. The cams were about 6 inches in diameter, and although they were enclosed in casings, the noise was so great that it was impossible to hear gongs, and consequently sight indicators for the engineer had to be installed. It was absolutely impossible to carry on conversation in the engine room, even though the speaker placed his mouth right up to the listener's ear and shouted as loudly as he could. It was even impossible to carry on conversation on the after deck, and the only place where a conversation could be carried on without shouting was on deck near the bow of the vessel.

The "bearing" pressures have been so high in some of these engines that it is necessary to use forced lubrication at considerable pressures to prevent the bearing seizing. This high bearing pressure the writer believes to be bad practice in engines designed for use in submarine boats. It may have proved satisfactory in destroyers or other high-power boats where there is plenty of room to have a sufficient number of oilers on continuous duty, and where they can "feel" the bearings.

In case of failure of the high-pressure oil lubricating system in a submarine, the engine is likely in a minute to be put out of commission for months. I have known of

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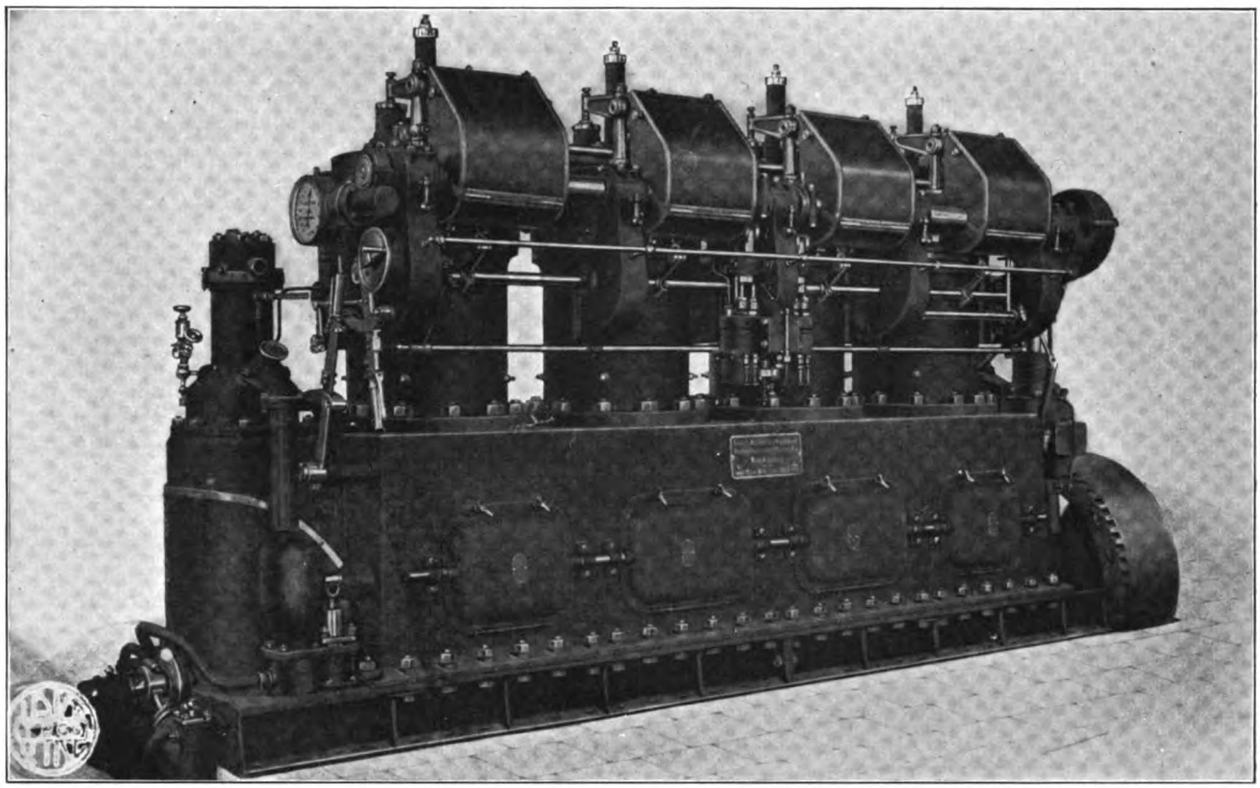

Fig. 36.—Augsburg Type Four-Cylinder, Four-Cycle Engine, as Used on a Number of German Submarines

This engine is said to have stood up very well in actual service. It is heavier per horsepower than some other Diesel engines, and not so complicated; while the four-cycle engine takes up more room than the two-cycle engine per horsepower developed, it is somewhat more economical of fuel and where high speed is not made the first consideration in the design of a boat, the four-cycle engine under the present stage of heavy oil engine development seems to have proved to be the most reliable under long-continued service.

engines being built where the pressures ran up to as much as 1,700 pounds per square inch on the main bearings and crankpins. Further, with these same engines I have known the engine force to work for weeks before they succeeded in getting the oil system to function in a satisfactory manner. Even where maximum explosion pressures have not exceeded 1,200 pounds per square inch, frequent heating of bearings have occurred, and it has been necessary to install water-cooled caps to permit the engines to be run at their designed speed and power.

SAFE BEARING PRESSURE

My experience has taught me that in submarine boats engines should not exceed 1,000 pounds per square inch of projected area on main bearings or crankpins.

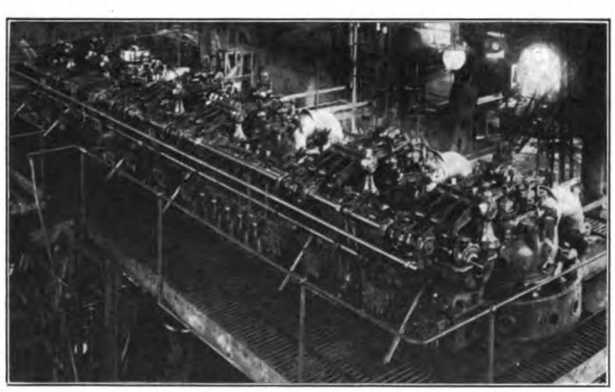

Fig. 37.—Complicated Mechanism on Cylinder Heads of European Reversible Diesel Engine

The great multiplicity of cams, levers, valves and their attachments accounts for the great cost of the Diesel type of engine over the ordinary four-cycle gasoline (petrol) engine. The mechanism has functioned very well on engines running at approximately 100 revolutions per minute, but when the speed is increased to 350 to 400 revolutions per minute, as is necessary in submarine-boat engines in order to get them into the small space available, the noise becomes terrific.

The engine is the most important element in the submarine. Without it, it is impossible to make long surface runs, and with it disabled, it is impossible to charge the storage batteries to enable the submarine to function submerged, which is, of course, what she is built for doing.

I think the demand for increased speed has come too rapidly. It is more important to have reliability than speed. The criticisms which have been made regarding United States submarines, if traced to their source, may be found to be justified as far as they apply to the engines, but the Navy Department cannot be held responsible, and neither can the designers of submarines. They have both searched the world's markets and secured the best that could be purchased. All naval departments were undoubtedly right when they decided to abandon the gasoline (petrol) engine and substitute therefor the heavy oil engine. Eventually a successful heavy oil engine will be produced.

The Diesel engine, weighing practically 500 pounds or more per horsepower, has functioned satisfactorily in land installations, and has come into very general use, especially in Germany, but when the attempt was made to change this slow speed engine of 500 pounds per horsepower, into high speed engines of approximately 50 pounds per horsepower, all designers "fell down." It was but natural that naval authorities throughout the world should call for increased speed, and they cannot be criticised for that, as it is a desirable thing, but experience has shown that they called for it too early "in the game."

The expense of the development of a new type of motive power, such as the high speed, heavy oil-burning engine, for use in vessels whose prime purpose is to preserve the autonomy of the country, should be borne by the govern-

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ment rather than individuals or private corporations. Millions of dollars have been expended in the development work of engines and the successful engine is not yet on the market, although vast improvements are now in progress.

DIAMETER OF CRANK SHAFTS

To develop 600 horsepower at 400 revolutions per minute, engine designers a few years ago thought 5-inch crank shafts were ample. When it is taken into consideration that 5-inch crank shafts have been used successfully to transmit 2,000 horsepower on a steam engine running at 400 revolutions per minute, one can understand that the designers of internal combustion engines may have been justified in thinking that they had a sufficient margin of safety in providing a 5-inch crank shaft for one 600 horsepower internal combustion engine. Experience has shown, however, that this is not sufficient. The reason why it is not sufficient has not been made entirely clear, as, according to all of the best engineering formulas, this margin would seem to be ample, taking the maximum stresses that could be brought to bear upon the shaft, but the fact remains that they have failed. My own opinion is that it is probably due to the heavy armature "close connected" to the engines. This armature weighs in modern submarine boats, several tons. The multiplicity of explosions which produces rapid acceleration with intervals of retardation may produce an effect similar to hammer blows which fatigue the material and cause failure.

I remember one instance in a certain European navy where engines failed, and a government commission was appointed to investigate the cause of failure. Expert engineers were called in to investigate the matter. The engines had functioned very satisfactorily indeed up to about 300 revolutions per minute. They were designed to give 600 horsepower each at about 375 revolutions per minute. The crank shafts were 4½ inches in diameter. There were twelve cylinders on the shaft. The shaft was the same size all through.

When the design of these engines was under way, the writer suggested that it would be a good idea to increase the diameter of the crank shafts towards the stern, as manifestly the load became greater towards the propeller. The engine builders maintained that the crank shafts were ample in size and guaranteed them to carry the load satisfactorily. The opinion of other engineers was asked, and they also advised that 4½-inch crank shafts were ample to carry the load at the revolutions stated. Consequently the engines were bought and paid for and were installed on board the vessels for which they were ordered.

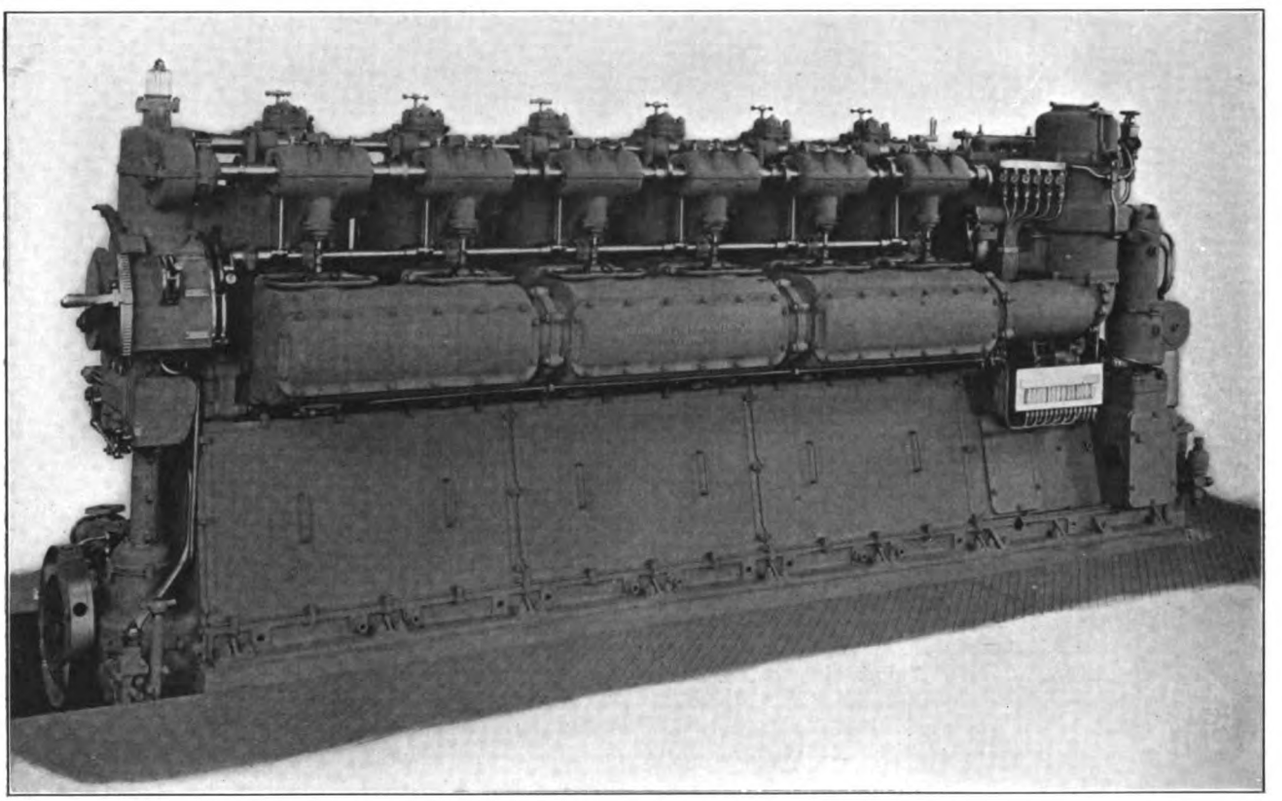

Fig. 38.—Sulzer Diesel Engine Used on Some of the Lake and European Submarines

Messrs. Sulzer Bros. were one of the early engine builders in Europe to take up and develop the Diesel engine, and several thousand men are employed in their works at Winterthur, Switzerland, building these engines. Several years ago they took up the development of an engine for submarine work, and have furnished such engines to European countries and also to the Lake Torpedo Boat Company in the United States. About three years ago a company known as the Busch-Sulzer Bros.-Diesel Engine Company, was formed in the United States to build these engines, and one of the most complete plants of the kind in the world was erected at St. Louis, Mo. Mr. Robert Sulzer is director of this company, and Dr. Diesel was himself a director up until the time of his death. It is believed that the engines now being constructed by this company will overcome many of the difficulties heretofore experienced in submarine engines, as referred to in the text of this article.

As previously stated, they worked satisfactorily up to 300 revolutions per minute, but when the time came to test them out under full load, the crank shafts twisted, commencing at the eighth cylinder, counting from forward to aft. After an attempt to run them at full load, the eighth crank was found to be twisted three degrees, with a progressive increase in each crank aft, and the last crank was found to be twisted over 45 degrees.

As these boats worked satisfactorily under all conditions except at full engine speed on the surface, the government

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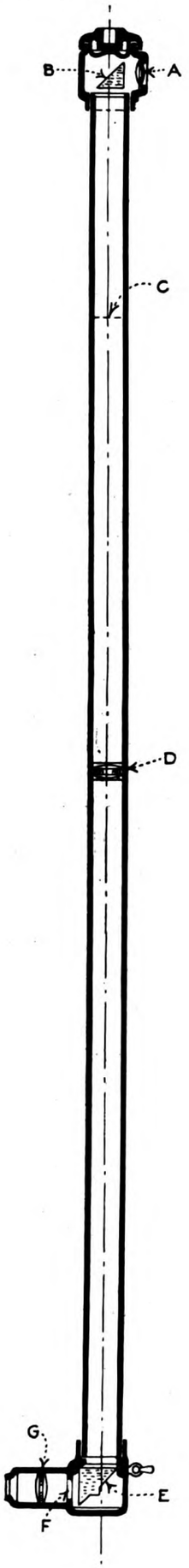

Fig. 39

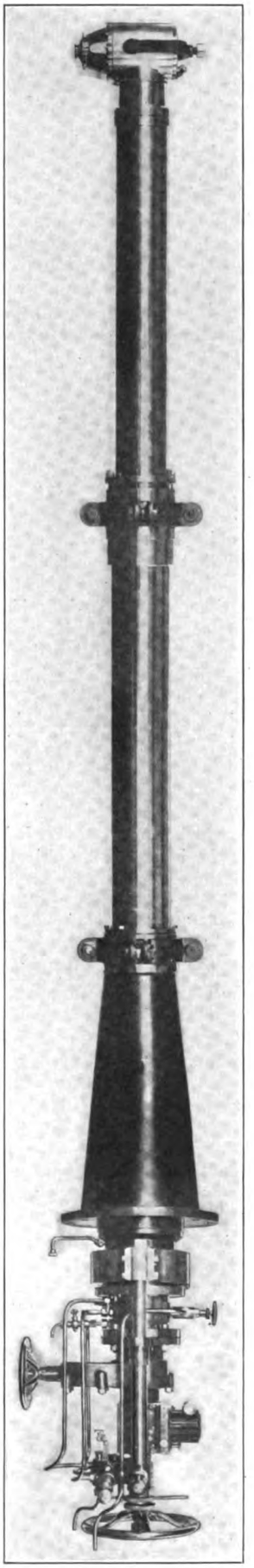

Fig. 40

stated that they would accept the boats, as they wanted to put them in commission at once, and they would themselves put in new crank shafts. These were the same engines for which the writer had recommended larger crank shafts, but not being an engine designer I was overruled.

When these crank shafts failed, the writer again recommended to the Government Commission that they put in larger crank shafts. This Commission took expert advice and held various hearings on the matter. Engineers differed. The ranking engineer on the Commission, after having had pulling tests made of the crank shaft that failed, claimed that the twisting was caused by the use too mild metal, and that if new crank shafts were installed of "Krupp" nickel steel, 4½ inches diameter would be sufficient to carry the load. A young engineer, with rank of lieutenant, on the other hand, claimed the crank shafts should be 6 inches in diameter.

The boats had been running in the meantime under the eight forward cylinders at about 300 revolutions, which gave them about 11½ knots, instead of the fourteen desired. Finally, after several months, the counsel of the

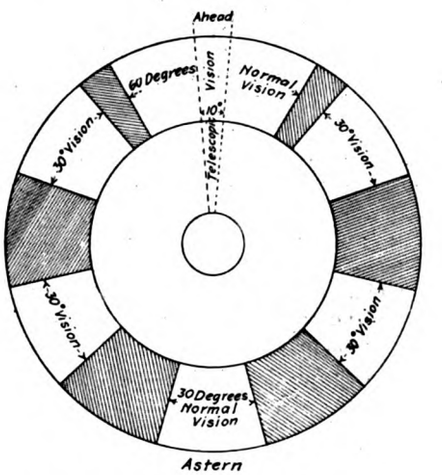

Fig. 41.—Field of Vision of Omniscope

The omniscope is an instrument which is designed to give normal vision covering a field of about 60 degrees ahead. It also gives telescopic vision of a magnification of eight to ten, straight ahead. It may also be arranged to give a complete view of the balance of the horizon at one time, but this cannot be secured and give normal vision at the same time, for the reason that we are accustomed to seeing with the normal eye only about sixty degrees of the horizon at one time. If we bring the entire horizon so that it is viewed at one time we do not get a correct impression as to distance. In other words, if we bring 360 degrees of horizon on to the retina of the eye, an object appearing in this horizon of 360 degrees appears to be much further away, as it is necessarily reduced to 1/6 in size, and we are accustomed to judging distance by the size of the picture which appears upon the retina or photographic plate of the eye. Therefore, the omniscope view is of no value for judging the distance; its only value is to denote the immediate presence in the vicinity of the submarine the instant the head of the omniscope appears above the surface.

senior engineer prevailed, and the government ordered new shafts of nickel steel from Krupp, and which, on attempting to run at full speed, snapped like pipe stems instead of twisting.

Later, engines of equal power were built with 5-inch and still later with 6-inch crank shafts, and in the last 600 horsepower engines that I had to do with I insisted that the crank shafts be made not less than 7 inches, which most engineers say is much heavier than should be required, but experience and unknown stresses made it, from a builders' point of view, advisable to have a surplus of strength rather than a failure, and I believe the general tendency is now to look for reliability rather than speed. This tendency is also manifested in our own government's latest requirements for submarine boat engines, in which they have eliminated the requirement for reversible engines and permit the installation of the simpler form of

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non-reversible engine, making it necessary when running under engines on the surface to cut out the engines and reverse under motors.

This seems a step backwards and undoubtedly is a halt in progress, but the department is undoubtedly fully justified, from its experience, in making a temporary "halt" to give the engine designer and builder an opportunity to "catch up," and undoubtedly engine builders throughout the world are making heroic efforts to "make good," but it requires months or years in some cases to bring to perfection a new and satisfactory design of such a complicated device as a reversible high speed, heavy oil engine.

Dr. Diesel has stated that he worked seven years before he succeeded in getting his first engine to make one complete revolution. Governments and the people must, therefore, content themselves to accept what they can get in a heavy oil engine, imperfect though it may be, until such time as a satisfactory engine is evolved, built and tested out under service conditions.

The illustrations accompanying this article, of some of the latest engines turned out by the most important engine builders in the world, will show that great efforts are being made to meet the demands of various governments for a satisfactory high speed, high powered, reversible engine, capable of economically burning non-explosive heavy oils.

PERISCOPES

The periscope is the eye of the submarine. In its simpler form it consists of a stiff metallic tube from 15 to 20 feet in length and about 4 inches in diameter. Referring to Fig. 39, it is made up of an object glass, *A*, which "views" or takes an "impression of all objects within its range" or "field of vision" and transmits an image of such object through the right angle prism, *B*, which turns the image so that it appears some distance down the tube—say for purposes of description—at *C*. If a field of ground glass were held at the focus of the objective lens *C*, the image could be seen, The lens *D*, located further down the tube, in turn now "views" the image and transmits it still further down the tube, where it is turned through the right angle prism, *E*, and where the image is again turned into an erect position. A piece of ground glass located at *F* would show the image in the same manner as an image is shown on the ground glass of a camera. The magnifying eye piece *G* magnifies the image so that the object appears of natural size.

Fig. 40 shows a periscope as made by the Officina Galileo in Florence, Italy. This firm makes periscopes with binocular eye pieces. The success of any periscope depends upon the character of the material used in the lenses and prisms and the accuracy of the workmanship. This firm, which is probably the oldest optical manufacturing house in the world, said to have been founded by Galileo himself, turns out instruments of the most beautiful workmanship. The flange of the instrument is bolted to the top of the conning tower or deck and a gate valve is arranged between the deck and the eye piece so that in case the tube should be carried away the gate valve can be closed, and thus prevent water from entering the vessel. A hand wheel arranged below the binocular eye piece permits of easy rotation of the instrument. Provision is made for introducing dry air, which prevents condensation forming on the lenses or prisms within the tube.

Owing to the fact that there is a certain loss of light in transmitting the image through the various prisms and lenses, it is customary to magnify the image so that it appears to be about one-quarter above natural size—that is, when viewing the same object through the periscope with one eye and the other with the natural eye, the object viewed through the periscope appears to be about one-quarter larger than when viewed by the natural eye. This has been found by experience to give, when viewed through the periscope alone from a submerged vessel, the impression of correct distance.

Previous to 1900 there was no instrument that would give through a long tube normal vision and a correct idea as to distance. At this time the writer took up with various opticians the question of producing such an instrument. They all contended that it was impossible to produce an instrument that would give through a long tube a field of vision equal to the natural eye or that would convey a correct idea as to the distance of an object when viewed through a long tube. The camera lucidia which Mr. Holland and others had used in the earlier submarines simply threw a picture of the object on a bit of white paper, usually located on a table. This did not give to the observer any more idea of the correct distance of an object than a photograph would. Believing, however, that a solution could be found, the writer purchased a variety of lenses and started making experiments.

Without any special knowledge of optical science, one day quite by accident, I secured the desired result and found that it was possible to secure practically normal vision through a tube of considerable length. About the same time, Sir Howard Grubb, of England, brought out an instrument in which he accomplished the same result. The writer then continued experiments and brought out an instrument which was designed to give a simultaneous view of the entire horizon.

This instrument was called an "omniscope." It was first called a "skalomniscope," which was a word coined with the idea of describing the function of the instrument and which, translated, means "to view and measure everything." A scale was used in connection with this instrument which would convert it into a range finder by measuring the image of an object of known dimensions, such as the length of a ship or the height of its smokestack, and give simultaneous reading as to its distance.

For a time it was necessary for us to manufacture our own sighting instruments, but later, when the optical houses understood the principle of the periscope, they took up the matter of manufacture and have greatly improved them, so that it is now possible to secure instruments of great accuracy and fine definition.

The periscope, however, is faulty, in that it is only an instrument for day use. As soon as dusk comes on the periscope becomes useless. The passing of the image down through the various lenses and prisms reduces the brilliancy of the image to such an extent that, even although it is finely magnified to above normal, the image is so thin that it cannot be seen. This forces the submarine to become vulnerable in making an attack at night, as it is necessary for the conning tower to be brought a sufficient distance above the surface of the water to permit the commanding officer to secure natural vision.

With the powerful searchlights and rapid-fire guns, the submarine would have little opportunity to approach a surface war vessel at night without great danger of being discovered and destroyed.

There is a device which the writer believes, however, can be successfully used for night work, which will be described in a later article.

(To be continued.)

The keel of the United States battleship *California* will be laid at the New York Navy Yard, Brooklyn, N. Y., on October 14.

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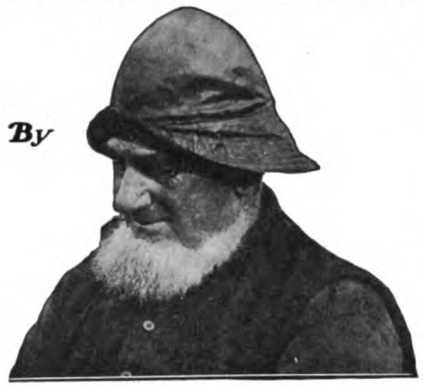
Economy Talks By "Old Scotch"



Some Suggestions About the Use of Zinc

They say that everyone at some time in his life has a chance to get rich, or, in other words, that Fortune knocks at every man's door at least once in his lifetime. Well, the old dame has knocked at every marine engineer's bulkhead door pretty hard more than once in the past year. What's that! You didn't hear her? Well, I didn't, either, but she knocked just the same, and it is my object in this particular issue to show you at least one place where she knocked, and knocked long and loud.

Zinc, you know, is a metal much used in all ships, principally in the boilers and around sea connections. About a year ago you could have bought all the block zinc you wanted for about eight or ten cents (0/4 or 0/5) a pound. If you have had occasion to purchase any recently, you have had to come across at the rate of about thirty to thirty-five cents (1/3 to 1/5½) a pound. If you had had a sufficient "hunch" and filled up a spare bunker with this metal at eight cents (0/4) the pound, you can easily see where you would have been walking along West street right now with your head in the air and whistling "I don't care if I never see the sea again," or some other classic like that.

Just think of it—a metal that we would kick around the fireroom and value it just a little more than burned-out grate bars to take a jump like it has and increase in value over two hundred percent in less than a year! If it keeps on like this, we will be making watchcharms out of it, or perhaps we will have our dentists digging it out of our teeth and substituting gold or platinum, or other cheap metals like those, in its place. They say "you never miss the water until the well runs dry," so if that is so we ought certainly to increase our fondness for zinc at an alarming rate to keep pace with its scarcity.

The object of this screed, however, is to make some suggestions about the use of zinc, so that we will not have to go broke by using it so much on our ships. Every marine engineer is trained up to know that brass or copper in close contact to steel or iron will result in the latter getting the worst of it when they are immersed in salt water. Hence we have all been trained to use goodly quantities of zinc around sea-valve openings in the hull and around propellers when bronze wheels are used, in order to save the iron or steel of the ship's structure. Our old friend—or our old enemy, in this instance—Mr. Electrolysis, gets in his work strong if we do not take the precaution of using zinc liberally on the ship's hull near anything that is made of brass or copper. The daily papers recently contained stories of the almost complete destruction of a half-million-dollar yacht (we will make it half of that sum, to keep near the actual cost) on her maiden voyage from Boston to New York, because due regard was not paid to this precaution.

It seems that the stern, stern post and rudder frame were made of wrought steel, and the yacht was plated with Monel metal, a natural alloy said to contain about sixty percent of nickel and fifty percent of zinc. It is also rumored that the plates were fastened to the frames and to each other with steel rivets. As Monel metal has much of the properties for active galvanic action as are possessed by the bronzes, the inevitable happened and the steel parts of the structure were rapidly disintegrated, causing the untimely scrapping of a very valuable yacht.

Of course, the answer is that the stern, stern frame, etc., should have been made of manganese or other similar bronze with which there would have been little or no galvanic action. It is always easy to see what causes such things after the damage is done, so I am not trying to criticise the designers or builders of this particular vessel. What I am driving at is that if you do not use metals which start up galvanic action it is not necessary to take precautions for preventing it.

This is particularly applicable to sea connections. Formerly it was the universal practice to fit all sea-valves of brass and to use brass strainers, copper injection pipes, etc. Now most of the up-to-date shipbuilders carefully avoid brass or copper around sea connections. Where formerly it was absolutely necessary to fit special zinc rings around all sea-valve openings every time the ship was docked, it is now not necessary, when steel plate strainers are used, and cast iron valves are substituted for brass. Some builders even fit the injection pipe of cast iron, and they work all right, too. I have seen a 10-inch copper main injector pipe renewed after only one year's service, because of holes pitted through it by galvanic action from the spelter which was used in brazing the joints and flanges.

Recently shipbuilders have adopted the expediency of casting a number of vertical ribs around the bodies of valves; and as the effect of the galvanic action does not reach these external ribs, the valve is supported in a cage-like structure, which makes them absolutely safe. At all events, by the elimination of brass and copper we are not compelled to fit the zinc rings around the openings in the hulls, and, "believe me," that saves some little expense when zinc is around thirty-five cents (1/5½) a pound, and threatening to go higher on account of the greed of the warring nations for this valuable munition.

Of course, for the time-being, while the high-brows are scrapping as to the value of different kinds of boiler compound in preventing corrosion and pitting, the prudent engineer will continue to use some zincs in the boilers. It is better to use some of this high-priced zinc than to sacrifice a ten-thousand-dollar (£2,140) boiler for the lack of it.

Yours for economy,

Old Scotch

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Questions and Answers for Marine Engineers

Inquiries of General Interest Regarding Marine Engineering and Shipbuilding will be Answered in this Department

CONDUCTED BY H. A. EVERETT *

This department is maintained for the service of practical marine engineers, draftsmen and shipbuilders. All inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given permission to do so. Indicator cards taken from marine engines will be carefully analyzed, the defects pointed out, and the horsepower calculated, provided complete data are sent with the cards.

Advantages of the Turret Deck Steamer

Q.—What advantage is claimed for a type of steamer often seen in different ports, similar to a whale back, having a narrow deck, the sides flaring out a little above the waterline? What is that type of construction called? C. D.

A.—The vessel you describe is what is known as a turret deck steamer, a type of construction originally brought out and patented by Doxford's in Great Britain, and has been very popular for the past decade for bulk freighters. They

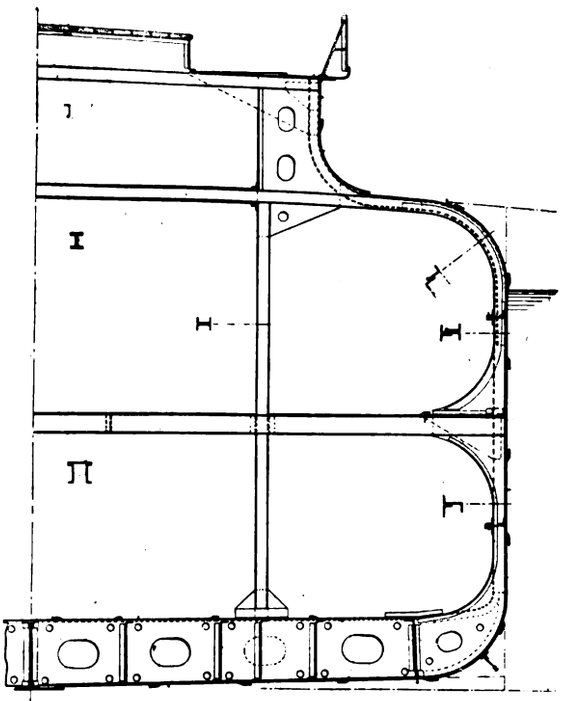

Fig. 1.—Midship Section of Turret Deck Steamer

were originally evolved for bulk carriers when the hold could not be filled entirely full, either on account of stowage or overloading. Cutting away the outboard parts of the upper 'tween decks served the double purpose of reducing the tonnage measurement and consequent port charges and providing a central trunk which served as an expansion chamber and also made the vessels self-trimmers when loaded with a cargo such as grain.

Incidental to these prime reasons were others of a constructive nature which helped keep the type popular, as they were cheap and strong (no sheer, long parallel middle body, etc.). But there are few built at the present time. They are inferior to the standard type in stability when heeled to an excessive angle. A modification of this

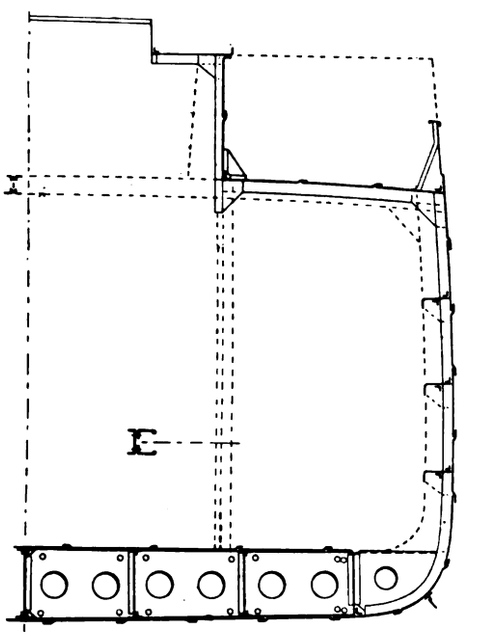

Fig. 2.—Midship Section of Trunk Deck Steamer

type built with square corners is called a trunk deck type. (See sketches.)

Stress and Strain

Q.—Will you kindly distinguish for me the difference in meaning between stress and strain? L. F.

A.—Stress, as defined by Morley, is "the equal and opposite action and reaction which takes place between two bodies or two parts of the same body when transmitting forces." The *intensity of stress* at a surface, generally referred to with less exactness as merely the stress, is the force transmitted per unit of area, in the case of uniform distribution.

Strain is the alteration of shape or dimension resulting from stress, and is measured by the fractional elongation or contraction. In general, we may consider stress as the force and the strain as the distortion which the force produces. It is improper to speak of a strain of so many pounds.

Heating Surface of a Corrugated Furnace

Q.—How do you figure the heating surface of a corrugated furnace of the Morison or Fox type? F.

A.—In estimating the heating surface of a corrugated furnace the makers figure it the same as that of a plain cylindrical furnace whose diameter is equal to the mean diameter of the corrugated furnace.

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Letters from Marine Engineers

Discussion of the Design and Handling of Marine Engines, Boilers and Auxiliaries—Breakdowns at Sea and Repairs

This department is open to all readers of the magazine for the discussion of affairs in the engine room. All letters published are paid for at regular rates. Your ideas or experiences will be mutually helpful and interesting to other engineers. Write your letter now.

Economy

Since the ship *X* has always stood well in engineering, it looked like a hopeless task to improve what had been so consistently good as to have made her generally known as a "star ship." To improve a ship that had been as notoriously bad in engineering could have been undertaken with more hope of success. Kipling described the condition as: "Yon's strain, hard strain, o' head and hand, for though Thy power brings all skill to naught, ye'll understand a man must think o' things."

"Old Scotch" has thought of the many "things," small things, and told them in his "Economy Talks" in INTERNATIONAL MARINE ENGINEERING. The big things had been thought of on the ship *X*, put into effect, and had become an old story, with the result that the plant was in an efficient condition. But that the "Old Scotch economy talks" can help in increasing existing efficiency is shown by the following table of performances:

Year	Knots per ton at 11 knots speed	Tons per hour at anchor	Speed maintained during a four-hour test
1911-12	2.56	.95	18.17
1912-13	2.59	1.08	18.04
1913-14	2.64	.73	18.36
1914-15	3.00	.66	18.44

As far as is known there has been no new scheme used or developed; there has been merely a systematic application of old wrinkles in engineering that have from time to time been published for the information of those "dissolute mechanics" striving to be drivers of engines and Irishmen. We have therefore tabulated what we believe to have been the producers of the above noted results, in the hope that some seafaring brother may have his day's work made easier.

PUMPS

In an inefficient plant the trouble has nearly always been placed at the door of the poor old pumps, so they were tackled first, and in three cases, three auxiliary feed pumps, they were found to run along just as merrily and clamorously with the discharge closed as with it open. These pumps have outside packed plungers which show a leaky plunger at once, and since the plungers were tight this made the trouble unmistakably in the suction and discharge valves.

The bonnets were removed and these valves seemed in good condition, but measurements showed the following: The valve seats (*a*) and (*b*) (Fig. 1) with the valve guards (*c*) (*c*) had been put in place and the nut (*d*) set up before the nut (*c*). Thus (*a* and *b*) were drawn from their seats (*f*) (*f*) and water could flow between (*b*) and (*f*).

The operation was then reversed, (*d*) removed and (*e*) set up; when (*e*) was well home then (*d*) was set up. Before again testing the pump the steam valve was spot faced on a face plate and the piston rings renewed. The tightness of the rings was then tested as follows: With the cylinder head removed the piston was shored from the crosshead to prevent upward motion and a steam hose connected to the lower drain cock of the steam cylinder and pressure raised to the pump's working pressure. A leak around the piston ring was thus easily detected.

The above-mentioned treatment was given to every pump—auxiliary condenser and dynamo circulating pumps included. Thus in all cases the pump piston speed has been reduced below 100 feet per minute.

To maintain this condition each pump is tested once a week by starting it up and then closing the discharge, or by having it build up pressure on a boiler. Also, weekly tests of the tightness of throttle and exhaust valves are made by closing them and opening the cylinder drains. We have been singularly free from pump troubles when prompt service was needed.

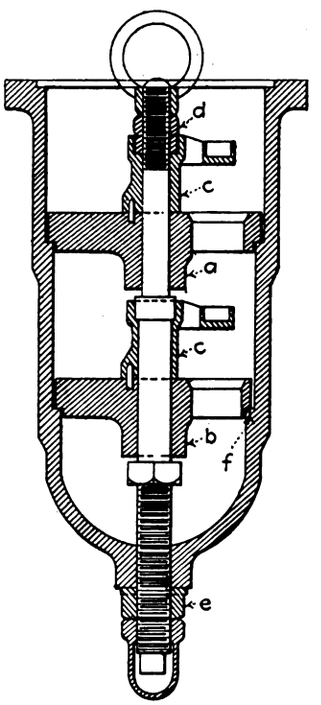

Fig. 1

TRAPS

The old tried and true test valves were put on all traps and they are tested by means of these valves once each day by an officer. If the test is not satisfactory the trap is cut out at once and the work of examining and repairing is begun, (*a*) and (*b*) (Fig. 2) being closed and (*c*) open while the trap is being tested.

At first some difficulty was experienced in getting the traps so they would operate. This difficulty was overcome by putting monel metal seats and valves in all traps, as shown at (*a*) and (*b*) (Fig. 3). The traps on the ship X are all old. The modern Keilly & Mueller trap is manufactured with valves and seats of monel metal. After the installation of the monel metal the repairs necessary on traps have been remarkably small. The work done on them since July, 1914, is as follows:

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October 29, 1914—Trap (Keilly & Mueller) in No. 5 fireroom leaking and valve ground in.

November 11, 1914—Trap (Keilly & Mueller) in No. 4 fireroom leaking and valve ground in.

November 19, 1914—Trap (Keilly & Mueller) to whistle line leaking and valve ground in.

April 24, 1914—Trap (Keilly & Mueller) in No. 2 fireroom leaking and valve ground in.

October 31, 1914—Trap (Keilly & Mueller) on anchor engine line leaking and valve ground in.

December 12, 1914—Traps (Lytton) dynamo line leaking and valve ground in.

February 2, 1915—Trap (Keilly & Mueller) starboard dynamo line renewed valve and seat.

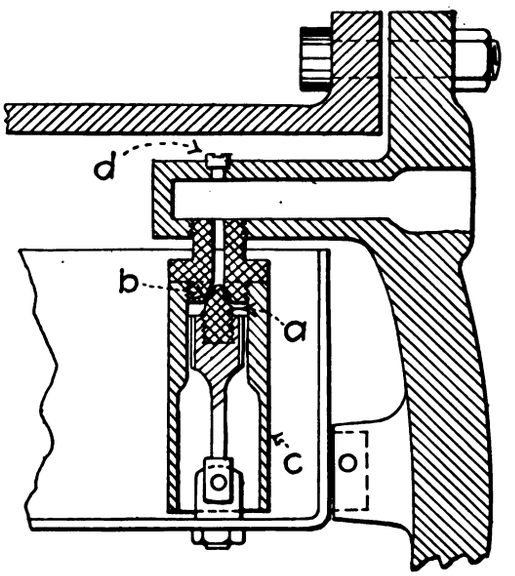

Fig. 2

March 3, 1914—Trap (Keilly & Mueller) in port dynamo line renewed valve and seat.

July 1, 1914—Trap (Keilly & Mueller) both main separators leaking and valves ground in.

August 21, 1914—Trap (Keilly & Mueller) port auxiliary steam line leaking and valves ground in.

When the discharge from a trap is rather prolonged it usually means that the pipe (*c*) is too short. A print was obtained from the Keilly-Mueller Company and fittings made so that in every case the trap conformed to the original drawing.

In two cases it was found that holes had eroded at the point marked (*d*). These holes were drilled and threaded and plugs inserted. This constant watching and care of traps has made them perform the twofold function of preventing live steam from being lost in the drain line and of keeping the steam lines free from water. The result has been practically no loss of water through leaky flanges and stuffing boxes and a great reduction of the work and cost of renewing packing.

BOILERS

The water being kept at 4 percent alkalinity or above, is considered to have been the salvation of the Babcock & Wilcox boilers of the ship *X*. The hard, thick scale that infested them was removed with a corresponding reduction in coal consumption. On account of gasket troubles it became necessary to reduce the alkalinity, but periodically the Navy Standard Boiler Compound is used to boil out a boiler. Then all of the tubes are wire brushed and all gaskets are renewed.

The cleaning of the fire side of a Babcock & Wilcox boiler has been a great problem. The use of the air lance was soon found to come under the category of "a lick and a promise," so the chain method of cleaning was adopted. The water tenders were won over to the chain method by permitting them to blow tubes by the usual air lance method, a light was then held on one side of the boiler and they were directed to look between the tubes from the opposite side of the boiler; not a ray of light could be seen. The chain method was then used and the light test repeated, revealing the passages unobstructed, the tubes clean, and the ash pans containing about eight buckets of soot and dirt.

The chain method of cleaning is used after each run.

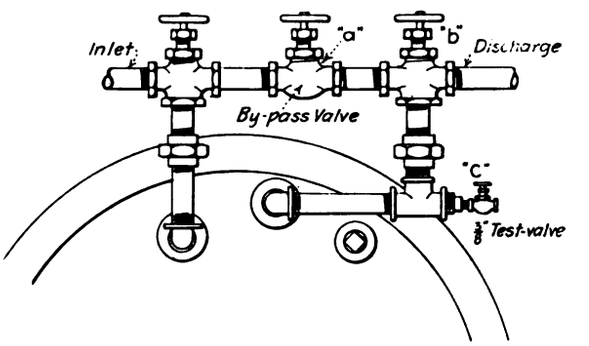

Fig. 3

This method, with the method of rectifying vertical and diagonal baffles, is given below. (See Fig. 4.)

(a) Remove all side doors, grate bars and the baffle brick on the 4-inch tubes that form the horizontal baffle over the forward part of the furnace. The brick removal is necessary for baffle work but not for cleaning.

(b) Clean the boiler thoroughly by hauling a chain back and forth between each row of tubes. This chain should have chain pendants 3 inches long attached to it at intervals of 4 inches throughout its length. The pendants drop down between the tubes and remove the soot lodged on the sides of the tubes. After the chain cleaning is completed the boilers should be blown with compressed air while the blowers are running. The object of this cleaning is so that the dirt and soot will not obstruct the men in their work by dropping into their eyes.

(c) Provide eight iron bars, ¼ inch by 3 inches, for each boiler. The position bars are to be long enough to project from 1 inch above the upper row of 2-inch tubes to 1 inch below the bottom row of 2-inch tubes. Insert these position bars vertically between the tubes from the furnace side, and abaft the baffle the position of which they are to locate. Two of the bars should be placed near the place where the baffles butt in the center of the boiler and the others at about half of the distance to the sides of the boiler. The bars are then clamped in position so that one edge marks the plane that the baffles should form. The position of the edge of the bar is located by taking the distance from the headers to the baffle plane and laying this off on the upper and lower 2-inch tubes. The bottom edge of the bar should be notched so as to form a rest on the bottom clamp to keep the bar from slipping down. The clamps for the bars should be made of ⅜-inch iron at least 2 inches wide. The position bar clamped in place is shown at *A* (Fig. 4). With the position of the baffle thus located the plates that are out of position can be detected by throwing the light from an electric torch on the position bars. This is done by observing from the side doors. If a space is noticed between the position bar and the baffle it will show the baffle to be out of place and leaking.

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(d) For forcing the baffles back into place three or more driving bars, shown at *B*, similar to the position bars above described, are provided. These driving bars should be long enough to reach from 6 inches above the upper row of 2-inch tubes to 1 foot below the lower 4-inch tubes. The driving bars are inserted in front of the baffles and clamps are made for them similar to the clamps described above and shown in Fig. 4.

So as not to break the plates that may be frozen to the tubes a preventer bar, marked *C*, is inserted on the horizontal, between the row of tubes where the baffle is out of place and between the plate and the driving bar. The idea of this preventer bar is the same as the use of a large timber on the corner of a dock when warping a vessel into dock. It will be found that the bar is not necessary for every plate, since some of them will go into place with the application of very little pressure.

The baffles are eased back into place until they touch the position bars. This is done by setting up on the top clamp of the driving bar *B*, and bringing pressure to bear on the lower end by means of a sledge, jack or wedges, then the operation is reversed—that is, the lower clamp, shown at *E*, is set up on and pressure applied to the upper end of the driving bar. By taking the tension easily on the three driving bars and by the use of the preventer bar, there is small likelihood of breaking any of the plates in getting them back into position.

(e) When the baffles are in alinement the driving bars and clamps used with them may be removed, but additional position bars should be put in front of the baffles to keep them in position. It is especially important that two of the bars should be placed near the ends of the plates, since the plates are most apt to separate at the place where the ends are supposed to butt.

(f) For holding the diagonal baffle down to the forward vertical baffle the following method has been found to give good results:

Brace a jack against the boiler drum and force the baffle down into position. After the baffle is in position a T-brace is put down between the tubes and turned so that the arms take on the bottom of the tubes; this is then placed against the vertical baffle and a hole drilled through the three—T-brace, vertical baffle and diagonal baffle. A bolt is then inserted and the nut set up on. This is shown at *F* and *G*. Four T-braces to each boiler have given good results.

The boiler plant of ship *X* consists of twelve Babcock & Wilcox thirty-header boilers. Until the completion of the above described baffle repairs it had been necessary to use two boilers for use in port at an average coal consumption of 24.2 tons per day. Since the completion of the repairs described one boiler has been found sufficient to supply all demands in port at an average coal consumption of 16.8 tons per day, or a reduction of 30 percent in the daily coal consumption.

For a time much trouble was encountered with chlorine in the boilers. Repeated tests showed the condensers to be tight. Then close observation and many tests showed that when water was run back from a boiler to the feed tank or to a reserve tank the water in the steaming boilers mounted in chlorinity. The bottom blow pipes were broken at the valves to overboard discharges at the sea stools. In each case these valves were found to be leaking, and that repairs to them could be safely made only when the ship was in dry dock. The old practice of blowing down boilers having gone out of vogue, the pipes and valves were blanked off, giving immediate relief from the salt troubles.

A bucket of powdered asbestos cement is kept in each steaming fireroom, and once each day the casings of the steaming boilers are tested for air leaks with a lighted candle, and leaks stopped.

After the completion of the above noted work on boilers two copper boilers were borrowed from the Landing Force Commissary Equipment and a boiler evaporative test conducted. This test was followed by a dynamo test and a test of the water consumption of auxiliary machinery with the results here noted.

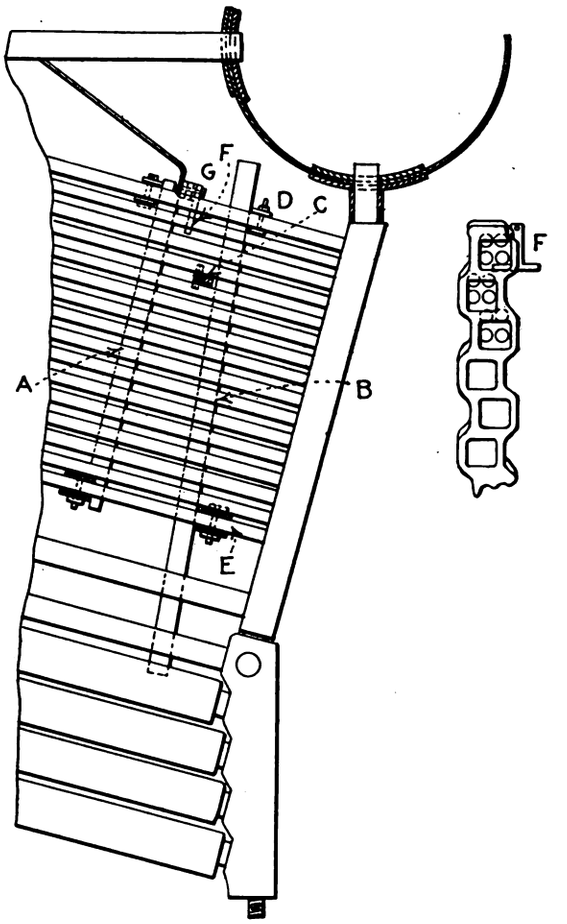

Fig. 4

Test Made on Babcock & Wilcox Boiler No. 7 of the Ship X to Determine Evaporative Efficiency

Kind of Coal.—Pocohontas, semi-bituminous coal.
Kind of Furnace.—Babcock & Wilcox six-door, thirty-header boiler.
Method of Starting and Stopping the Test.—Flying.
Grate Surface.—111.83 square feet.
Water Heating Surface.—4,698 square feet.
Superheating Surface.—None.

Total Quantities

1. Date ..... May 25-26, 1914
2. Duration of trial ..... 24 hours
2. Weight of coal as fired ..... 37,270.5 pounds
4. Percentage of moisture in coal ..... 1.07 percent
5. Total weight of dry coal consumed ..... 36,871.7 pounds
6. Total ash and refuse ..... 1,823 pounds
7. Percentage of ash and refuse to dry coal ..... 4.94 percent
8. Total weight of water fed to boiler ..... 334,837 pounds
9. Factor of evaporation $\frac{1{,}198.75 - 196.5}{965.7}$ 1.038
10. Equivalent evaporation into dry steam .... 347,560.8 pounds

Hourly Quantities

11. Dry coal consumed per hour ..... 1,536.3 pounds

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12. Dry coal per square foot of grate surface per hour, 13.738 pounds
13. Water evaporated per hour.....13,951.5 pounds
14. Equivalent evaporation from 212 degrees...14,481.7 pounds
15. Equivalent evaporation from 212 degrees per square foot heating surface per hour.....3.082 pounds
16. Steam pressure by gage.....188.8 pounds
17. Temperature of feed water entering boiler....227.4 degrees
18. Draft in inches water.....natural

Economic Results

19. Water apparently evaporated under actual conditions per pound of coal as fired.....8.984 pounds
20. Equivalent evaporation from and at 212 degrees as per pound of coal fired.....9.325 pounds
21. Equivalent evaporation from and at 212 degrees per pound of dry coal.....9.426 pounds
22. Equivalent evaporation from and at 212 degrees per pound of combustible.....9.916 pounds

Efficiency

23. Calorific value of dry coal per pound.....14,100 B. T. U.
24. Calorific value of combustible per pound....14,750 B. T. U.
25. Efficiency of boiler based on combustible....64.92 percent
26. Efficiency of boiler based on dry coal.....64.55 percent

The dynamo and auxiliary machinery tests gave the following results:

Auxiliary machinery in use for 24 hours.....	111,000
2,200 K. W. H. at 48.1 pounds water per K. W. H....	110,630
12,000 gallons fresh water distilled at 5 pounds per gallon	60,000
Total.....	281,630 Pounds of water per day

With this data tables were made out for the coal consumption of each piece of machinery for one hour at a given speed. This made it possible to charge each machine with the coal that it had used, then by taking the time that each machine had been in operation during the day and applying to it its cost in coal a list of consumption is obtained the sum of which gives a very good check on the amount of coal that should have been burned in the boilers for any given day. If a large discrepancy creeps in, it shows at once that either error or inefficiency are present and a search can at once be instituted. This further makes it possible to obtain the interest and co-operation of the users of power in reducing coal consumption by being able to keep constantly before their minds the amount of coal that they are expending. For instance, that delaying to give orders to secure a deck pump because it is going to be needed again in two or three hours means throwing away 60 pounds of coal per hour, or in the case of air compressors, 200 pounds of coal per hour.

After a short time a fair average consumption for each department was obtained and continued returns above the average show an excessive use of power in that department. It is then easy to trace out and rectify this lack of supervision and reduce the consumption to normal. Thus each man knows that there is always a check on him. The water tender on watch is credited with the consumption of the various machines in operation during his watch and charged with the amount of coal that he has had to burn. If the accounts do not nearly balance, searches for the leak are begun.

As an illustration of the above the following is given: (Before the effects of the "small things in economy" were begun to be felt, the only date on which one boiler was used for port consumption was on September 3, 1913; the writing of this letter happens to have begun on February 14, 1915; hence the choice of the performances on those two dates for illustrations):

September 3, 1913		Coal
Steam to galley.....		1.00
Coal to steam launches.....		2.70
Making 8,000 gallons of fresh water.....		2.00
Electricity—2,600 K. W. H.....		6.22
Auxiliary machinery	Pounds water	
Ice machine	16,900	
Main feed pump	12,792	
Flushing pump	12,504	
Fire and bilge pump	1,273	
Auxiliary condenser	12,090	
Air compressor	931	
	56,490	2.80
Coal allowed		14.72
Coal used		18.20
Coal wasted		3.58

February 14, 1915		Coal
Steam to galley		1.00
Coal to galley		.60
Coal to steam launches.....		1.30
Making 15,600 gallons of fresh water.....		3.90
Electricity—1,900 K. W. H.....		4.60
Auxiliary machinery	Pounds water	
Ice machine	15,600	
Main feed pump	12,792	
Flushing pump	12,504	
Fire and bilge pump	8,274	
Auxiliary condenser	9,672	
Ash hoisting engine	930	
	59,772	3.00
Coal allowed		14.40
Coal used		14.00
Coal saved		0.40

The allowed consumption in each case being practically the same, the saving may be taken as approximately four tons.

Heating System

It was found that about 10 pounds pressure was required on the heating systems to pantries and warming tables, and that when the evaporators were running the pressure on the drain line would mount to twenty-five pounds if the drains to the tanks were closed. It was then worked out as a good plan to use this heat in the pantries instead of discharging it into a condenser. This was done, the drains finally reached the tanks much lowered in temperature, and satisfaction was maintained among the stewards.

A further connection was made to the heating manifolds and enough heat thus obtained for all officers' quarters when the temperature of the outside air is not below 35 degrees.

Exhaust Steam

The back pressure on the exhaust line is usually carried at about 13 pounds to supply heat to feed water heaters. At first this gave considerable trouble in producing water hammers in the line, which on three occasions ruptured the pipe. This was remedied by installing two drain lines, one in each engine room, from pockets abaft the feed heaters. These lines seemed to relieve the hammering and at the same time increased the temperature of the water in the feed tanks to which they were given a direct lead.

In each fireman's wash room there is a steam jet used for heating water. The line to these jets was connected to the auxiliary exhaust line, thus having heat always available for the firemen in sufficient quantity for their satisfaction and at a cost much less than of live steam.

There was a convenient valve for making a connection for using exhaust steam for warming up the main engines. This connection was made and has proven to be very valuable in warming up the main engines without cost. This is particularly noticeable when operating on the drill grounds where "stand by" orders are very frequent.

The attempt has been made to use all of the heat that leaves the boiler in the steam without having any of it dissipated in the condenser. Water only is wanted back from the system and that can be made to serve a better purpose by being sent directly to the feed tank to expend all of its heat in raising the temperature of the feed water than by having it first cooled off in a condenser.

Comparative speeds of the circulating pump of the auxiliary condenser are given below:

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	September 3-13	February 14-15
Strokes per minute	24	18
Piston speed, feet per minute	48	36
Back pressure on auxiliary exhaust	21 pounds	28 pounds
Temperature of feed water	205 degrees	224 degrees
Temperature of feed tank	114 degrees	134 degrees
Temperature of injection	78 degrees	74 degrees
Vacuum	18 inches	24 inches
Steam pressure maintained	184 pounds	215 pounds

Ice Machine

Although the 3-ton Allen dense air ice machine had been giving satisfactory results, it was thought that a small amount of coal might be saved by testing it, so indicator cards were taken on both the steam and expander cylinders.

The cards obtained showed one end of the expander cylinder developing 10.4 indicated horsepower and the other end 7.5 indicated horsepower. A valve adjustment gave eight indicated horsepower on each end and a noticeable difference in the running of the machine as to speed, noise and temperature of the cold storage.

The averages for the weeks of which September 3, 1913, and February 14, 1915, each formed a part are here given:

	September 3-13	February 14-15
Revolutions per minute	67.7	60.0
Compressor pressure	241.0	240.0
Expander pressure	65.7	68.0
Temperature of cold storage, minimum	18.4	10.7
Temperature of cold storage, maximum	43.5	25.0
Injection temperature	77.4	75.0
Piston speed, feet per minute	158.0	140.0

Firing

The time firing device is used at all times, the interval between charges being such as will supply the steam demanded. This interval may vary from one to six minutes.

The routine of cleaning fires at regular intervals has been abandoned. When clinkers form they are removed. We made one run of eight days without going through the old-fashioned "clean two fires each watch," and found the "knots per ton" at the end of the run as good as at the beginning.

In tracing back the causes for increased coal consumption it has rarely been found that the firemen were at fault, but their actions have frequently been used as a gage. When the firemen were noticed hustling around slamming down slice bars and shovels and yelling at the coal passers to rustle out more coal, it was at once known that something was wrong, and when the trouble was located it was pretty certain not to be in the fireroom.

U. S. S. *Nebraska.* Lieut. F. H. Sadler, U. S. N.

More About Economy

Some time ago "Old Scotch," in his very enjoyable and instructive remarks, told about getting along with very little oil when one had to, and he commented on the waste of oil in general. This brought to mind what I am going to tell you about.

Having been in the past a good deal of a wanderer, I have had many bosses, all of whom had the idea of economy constantly in mind, but their economy was always of the spotted variety. One man was death on saving oil; another was hotfoot after coal saving, while a third would go wild if you broke a manhole gasket or used an ounce too much waste; but they all agreed on one point of economy, and that was my salary—on this they were a unit.

Four of us engineers were in charge of four small boats which for a part of the year ran a very few trips daily, but during the rest of the year it was hustle from five in the morning up to nine or ten o'clock at night; so we and the firemen thought we ought to have a little more pay, and asked for it and got "no" for an answer. Just as the slack time came on we were notified that our superintendent had resigned and a Mr. Benson was to take his place, and that Mr. Benson wanted to see us the next Sunday morning at his office, which was on the dock at the end of our run. The offices were up-stairs and the passenger and freight rooms below, with a room fitted up with a lathe, shaper, drill press and emory wheel. These tools, however, had never been used to any great extent.

Mr. Benson began his conversation by handing each of us a cigar. He was a small man, about fifty-five years old, and had gray hair and gray eyes with small crow's-feet in the corners—a sure sign of good nature, but also a warning not to get too fresh. Mr. Benson continued his conversation by saying: "Upon looking over the records I find that you men have asked for more pay. I know what your work is and how you do it, and I think you should have what you ask for; so I asked the directors to let me lift you a little, but they declined. I had looked over the records and knew what the average cost had been the last three years for coal, oil, gaskets, etc.; also what it had cost to overhaul each one of the boats, so I put it up to the board to allow me the average of these costs for next year, and if I could effect any saving that saving would be divided between you and the firemen.

"After some talk they agreed to allow the last three years' average of these expenditures of upkeep and running, less 10 percent, and anything that could be saved should be divided between you and the firemen, you taking 60 percent, the firemen getting 40 percent. I knew you men had all learned the machinist's trade, and, with a little shop downstairs you could make all the repairs necessary to the engines. As the hull repairs amount to very little, they cut no figure, anyway, so I only counted on the motive power for repairs.

"During the slack months we could lay up two boats at a time, and I am sure that by looking after things more carefully than you have done, and will have to do, you can make a saving worth while. What do you think?"

We talked it over and agreed to the idea. Then Mr. Benson went over to his desk and brought back an oil cup. He unscrewed the cover and, taking a toothpick from his pocket, shoved it into the hole in the stem.

"Now, you notice," said he, "that this hole does not go through into the cup. You could fill that cup with oil and put it up on that shelf and it would stay full for all time. Now, here is a little boss cast inside the cup, running up part way, and in that boss you see a little drilled hole. This runs down and meets another hole that is drilled in the bottom of the cup, which in turn meets the hole in the stem. Just above this small hole in the boss you will notice this spoon-shaped piece.

"The cup is good only where there is a reciprocating movement. The idea of it is that you fill the cup to the top of the boss only; when the cup is not moving the oil will not feed, but every time that the cup goes round with the crankpin or up and down on the crosshead the oil is thrown on the top of the boss and feeds down the small hole to the bearing. That hole is mighty small, and I know by the way you men look that you do not believe that enough oil will get down that hole to oil the crankpin of a one-'mouse power' engine, but I will put it on and show you that it will."

And he did. Now, that hole was made with about a No. 60 twist drill. We went right downstairs and put four of these cups on my engine, it being a compound. I took off the sight-feed drip cups and I measured up what one of them would hold, and found that the new cups held a little bit more. We used to fill the old cups twice on a round trip.

Next morning I found Mr. Benson in the engine room

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when I got down, and also one of the engineers. I felt pretty nervous, for I was sure that that dinky little hole wouldn't feed oil, and that I would have to overhaul the crosshead pin and brasses when I got back.

Our first stop was about five miles off, and when we made it there was nothing hot. Our next stop was about the same distance, and here we stopped half an hour where I had usually filled my oil cups, so I unscrewed the top of one of the new oil cups with the idea of refilling it, but I give you my word, Mr. Reader, that there was hardly any of the oil gone out of it. So I told Mr. Benson that the cup could not be feeding. He laughed and told me to screw the cap on again. Pretty soon off we went to our starting point. I unscrewed the cap a second time, and the cup was still three-quarters full. We put the cups on all the other boats, and since that time I have put the cups on a number of engines.

If I remember rightly, the man who made these cups was named Bangs. I never knew where his office was, and I do not know whether the cups are now to be found in the market, but I do remember that they were awfully expensive for first cost, a half-pint cup costing something like $16 (3/6/3). Perhaps some of the readers of INTERNATIONAL MARINE ENGINFERING have used these cups, and it would be interesting to hear from them.

The scheme proposed by Mr. Benson worked out satisfactorily to us all.

Yours for economy,

New York. JACK.

Organization of an Engineering Reserve for the Navy

Two articles appearing in a recent issue of the *Journal of the Society of Naval Engineers,* entitled "Organization of the Engineer Division on Board a Man-o'-War" and "Engineer Department of Naval Vessels," are strong appeals for "scientific management" in the engineering departments of our naval vessels. When engineering methods and routine are standardized, we surely will have a far more efficient engineering department in our navy. Such efficiency must be worked out and maintained by the officers and men in active service.

There never will come a time when it can be said of any organization that a state of perfection has been reached. The officers and men of any organization must never have the satisfied feeling of having attained perfection. As soon as this spirit is manifest in any organization it is a sure sign of decay.

In maintaining high standards of efficiency the purpose of the organization must always be kept before the members. Therefore, let us ask "What is the purpose of the engineering department of the navy?" In brief, the answer is "To make our navy an efficient fighting unit for the protection of the nation."

When the real test—war—is put to any military organization, efficiency demands that every fighting machine be fully manned by men familiar with their duties. It is hardly ever practical or desirable that all the men necessary to full fighting efficiency be carried in active service. It is necessary, therefore, to have an efficient reserve. It is the purpose of this article to suggest such a reserve for the engineering department of our navy.

The most valuable men in this reserve would be those who had at some time served in the engineering department of naval vessels. Such men should be listed and classified, and should form the backbone of the reserve. Having done this, the different groups should be formed. The man to be in charge of each group should be designated and given a list of ex-navy men in his group. These ex-regulars would form the nucleus of each group, but not necessarily the total number of the group.

In estimating the number necessary for an ample reserve, the following points would have to be kept in mind: (1) The existing shortages of men; (2) the probable vacancies that would occur during a state of war; (3) the number of vacancies occurring each year due to additional ships, etc.; (4) the number of vacancies occuring from all other causes, such as death, disability, etc. With this information carefully worked out, it would be possible to arrive at the number of men that should be carried in reserve.

The groups should be formed, the headquarters of each group being designated. The one in charge of each group should be furnished with a list of the ex-regulars assigned to his group, and the number necessary to make his complement full. If the number of regulars falls short of his full complement he must at once take steps to fill out his command by enlisting more men.

The enlistment term should be for the same length of time as men in the active service. When once a man has joined the reserve the discipline should be such that the serious purposes of the organization will be fully realized.

The meetings should be regular and all members should be required to be present at each meeting. At these meetings the men should be drilled and instructed in their duties according to their ratings.

The Navy Department should be kept in close touch with each group through those in command. The reserves should be kept informed of the latest methods and practices, etc., of the active service; and if possible given opportunities to take short cruises on board regular ships of the line.

When the members of the reserve organization are actually doing active duty, either on a practice cruise or in an emergency, they should receive the regular pay and allowances according to rank or rating the same as the men on the active list. Places of meeting throughout the year should be provided without expense to the members of the organization and incidental expenses should be provided by the Government. The members should also be provided, without cost, with drill manuals, copies of fleet regulations and all orders, general and special, issued by the Navy Department. In short, everything possible should be done to keep the reservists in as close touch as possible with the regular service.

The advantages of such a reserve worked out in detail along the lines mentioned cannot be overestimated. In the event it should be necessary to call for more men, in time of war, preparatory orders could be issued to those in command of all the reserve groups. There would be no confusion; the men would assemble quietly and hold themselves in readiness. They would know their stations and general duties. In fact, if the organization has been carefully worked out each man's duties would be clearly mapped out.

Compare this method to that of getting the men at the last minute. Picture the confusion resulting from a general rush to places of enlistment! Think of the mass of raw material that would have to be drilled and organized and weeded out! The national crisis could be such that every day lost would be so costly that months of fighting would be necessary to gain the advantage.

Let us never lose sight of the fact that our navy is a fighting machine, organized for the protection of the nation. The time to work out and perfect the smallest details in the organization of the engineering department of the navy is in time of peace. It behooves every thinking man to think, and think hard, make suggestions, and give his services if required.

St. Louis, Mo. ARTHUR C. MEYERS.

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Marine Articles in the Engineering Press

Stability Calculations and Experiments on Stability—Investigations of the Propeller Stream—Shipbuilding Contracts

Model Experiments for Stability of Motion of Submarine Boats.—The article deals with model experiments for determining the factors for stability of motion of submarine boats. It is shown that a certain force of reaction, varying with the longitudinal inclinations, will manifest itself ultimately by a depressing force and a tipping moment. To establish stability of motion this latter moment has to be controlled and counteracted by the after horizontal rudders. A description is given of the apparatus at the tank, which, by sliding rods and indicators, gave the resulting reactions for inclinations up to 4 degrees forward. The gradually advancing position of the reaction force is shown to indicate the relatively desirable amount of trim ballast and the point of coincidence of C. G. and reaction—in the investigated case at about 1½ degrees forward inclination—which requires no action of after rudders for stability of motion. It is concluded that by such model experiments it would be possible to closely predetermine the most desirable form of hull and appendages. 11 illustrations. 2,550 words.—*Schiffbau,* February 10.

The Form of the Propeller Stream and Its Energy Changes.—The energy in the stream thrown aft by a ship's propeller is lost for the ship, but is of importance in its dissipation for the surrounding canal banks. The author points out that the investigations in the German government tank have shown that the erosions of canal bottoms were nearly exclusively due to the influence of the screws and not the hulls of passing vessels. Experiments are recorded where measurements by Pitot tubes over the entire disk area of the propeller were made for the changing velocities of the streams, fully aware of the deflecting influence by the rotation of the screw. Three arrangements are described: screw alone with board cover, screw on ship without rudder, and screw on ship with rudder with seven stations increasingly distant from the propeller. High and low foci are found to occur, gradually spreading from the central disk to a much larger flat oval with a twisting pitch of about 37 degrees of these high and low speed spots. An important conclusion is drawn by the author from the curves of the third case of the ship fitted with rudder. Here curves of stream lines of considerable speed are deflected toward the bottom of the canal with pronounced eroding effect. In the first two cases without rudder the lines of any perceptible speed rise and spread out near the surface of the water, leaving the bottom practically intact. 22 illustrations, 2 tables. 2,060 words.—*Zeitschrift Vereines des Deutscher Ingenieure,* July 24.

Experimental Methods at the German Government Tank, Berlin.—(Fifth chapter.) In this chapter the author gives the manner of conducting trials of hydroplanes with water as well as air propellers. To realize a close approximation of the actual trim and lift condition of the hydroplane hull the supporting connections of the model to the traveling carriage of the tank are described as made in flexible and fully balanced form, allowing even for the upward component of the propeller thrust. From the recorded resistance and horsepower curves at different speeds it is shown that a suitable propeller can be selected in the manner previously mentioned; note is taken also of the Admiralty coefficient, which in this class of boats is rising in a remarkable manner with increasing speed. It is stated by the author that the change from water propeller to air propeller still leaves the problem quite well defined, as the propellers, apparently so widely differing, still have almost completely the same efficiencies at corresponding slips and allowance only has to be made for the different densities of the media. It is pointed out that the nominal slip is not of the same value as a recording basis for air propellers, and the practice at the tank employs a function of speed divided by revolutions by diameter as the basis for record. Upon a numerical example the different successive slips are given for determination of the necessary horsepower that with an air propeller will drive a certain hydroplane at a certain speed. 11 illustrations. 2,000 words.—*Schiffbau,* July 28.

On the Execution of Stability Calculations.—This article takes note of the fact that so far stability calculations have been considered satisfactory if they found the horizontal righting arms for a number of single conditions which offered, however, no check control on accuracy. The author mentions an inter-relation between the statical righting arm curve and the dynamical way curve found from the vertically measured positions of the varying centers of buoyancy, which enables the calculator to obtain such a check, although frequently with disappointing results regarding their agreement. The plea is made that the methods in the execution should be more closely watched for inaccuracies. It is pointed out that sectional area curves and moment curves are often so irregular that numerical methods like Simpson's or Tchebycheff's give rather misleading results, due to erratic knuckles of the inclined planes. The employment of a planimeter or integrator is therefore considered the very essence of accuracy from curves, as necessarily drawn up for each inclination. The author considers this method so trustworthy that he shows it calculated on an example for the horizontal position, as well as with a full new set of curves for the vertical position of the center of buoyancy. The method is pronounced also desirable for determining the value of the curve of cubes of the half ordinates in the determination of the metacentric radius of upright conditions. 3 illustrations. 2,100 words.—*Schiffbau,* August 11.

Some Technical Aspects of Shipbuilding Contracts.—By H. Bocler. The object of this article is to briefly consider how the shipbuilder in actual practice deals with the preliminary considerations entailed by contract guarantees or requirements in regard to deadweight and draft, cubic capacity, trim, stability, flotability when damaged, strength, speed and power, and to explain the nature and form of calculations which the author has found convenient for this purpose. Strictly speaking, the various technical factors react upon one another and cannot be considered separately, their final relationship in a particular case being evolved by a process of trial and error. For descriptive purposes, however, each factor is treated independently. Guarantees in regard to deadweight at a given draft involve three main considerations—freeboard, fineness of ship and light weight of ship. Freeboard is settled by law and presents no further uncertainty than that involved by a possible wrong interpretation of the freeboard tables. The question of fineness is best considered in re-

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lation to speed guarantee, and in so far as deadweight guarantees are concerned may be considered a known quantity. The chief element of uncertainty occurs in respect to the light weight and considerable experience is needed to form a reliable estimate of this. Builders' margins on deadweight should, therefore, be considered as a percentage of the light weight and not of the deadweight. In the case of passenger vessels a margin of at least 2½ percent should be allowed, while in cargo ships 1 to 1½ percent should be sufficient. The principal methods of estimating light weights are: (*a*) By coefficient, (*b*) by the use of curves, (*c*) by comparative estimating from a vessel already built, or (*d*) by calculation in detail. (*a*) is very approximate and should be used for first approximations only, (*b*) does not provide sufficient accuracy for a particular case, and should be used for only rough approximations, (*c*) is the most reliable method, while (*d*) is a long and tedious process and presents greater chances of error than the comparative method. It should only be employed when no suitable basis ship is available for a relative calculation. Guarantees in regard to cubic capacity can, as a rule, be agreed to without great risk. The unknown element lies mainly in the approximate nature of the method adopted for preliminary calculations made before the "lines" are designed. Without "lines" a margin of 2 to 3 percent should be allowed, but where "lines" are available for a detailed calculation of the capacity, 1 percent should be ample. The following methods are useful for estimating capacities: (*a*) By coefficient, (*b*) by geometrical variation of form. The latter method is very accurate and convenient when a suitable basis form is available. Guarantees as to trim involve two main considerations, the adjustment of weight and buoyancy to suit a basis condition (generally the load condition), and the relative trim under different conditions of service, a matter which is practically independent of the position assigned to the center of buoyancy to suit the basis condition. The question as to the amount of stability a vessel should possess is a difficult one and is not considered in this article. The usual contract requirement as regards stability is for a certain metacentric height under certain specified conditions. The determination of the metacentric height involves two factors—the form of the vessel and the vertical distribution of weight in the stipulated condition. The writer points out that in practice there is usually a tendency to underestimate the vertical height of the center of gravity, especially in the case of large passenger liners. A suitable margin for vessels of this class seems to be an allowance of at least 4 inches higher than the calculated figure. The remaining contract guarantees are to be taken up in a later issue of the magazine. 4 illustrations. 7,000 words.—*The Shipbuilder,* July.

The Exploration Ship Albatross, of the Zoological Station in Rovigno.—After giving a short historical account of the development of the zoological station in Rovigno, on the Adriatic Sea, in connection with the Berlin Aquarium, the author points out that the need of a special vessel led to a consideration of the most suitable type and size of craft for this special purpose. Two different sizes of vessels were considered—one about 37 feet long, the other about 53 feet long. The latter type was chosen, and its construction was ordered at the Havel shipyard in Potsdam. The characteristics specified for the vessel were as follows: Wood hull, seaworthiness, good speed, quarters for accommodating two or three scientists for several days at a time; a clear after deck for working the nets and sorting the catch, accommodations for a small crew, and low cost of operation, with a cruising radius of several days. The auxiliaries included a net winch, an auxiliary air compressor, a dynamo and searchlight, a windlass for anchoring in water up to 160 fathoms, a deep-sea sounding winch for working up to 2,200 fathoms. With skillful design, these characteristics were incorporated in the vessel, and the equipment was successfully located in the somewhat cramped quarters. The dimensions of the hull are: Length, 53 feet 4 inches; beam, 13 feet 6 inches; depth, 9 feet, and maximum draft, 6 feet 4 inches. The motor is an 80-horsepower, 2-cylinder, double-piston Junkers, 7 inches diameter by 10 inches stroke, crude-oil engine, arranged forward. The crew is berthed forward and the captain in the pilot house, while amidships is a living room with berths for four or five persons. Aft of the living room is a passage on the starboard side and a scientific laboratory for two or three scientists, with tables, lockers and two berths, as well as a toilet on the port side. In the stern is a fish bin with glass top and a lazarette for sails and nets. To get the necessary head room, a trunk about 20 inches high is provided over the living quarters. The pilot house has an adjustable searchlight, which can be housed in a box aft; also, the necessary steering and navigating appliances. The main engine shaft is fitted with a reverse coupling for a three-bladed feathering wheel. The oil tanks have a capacity of about 2 tons, which is sufficient for a five-days' run at full power. All of the auxiliaries are driven by belt or gearing from a 4-horsepower motor. The vessel has a ketch rig, and the composite hull is classed by German Lloyds. The trials proved satisfactory, and only the outbreak of war prevented the vessel from entering service at her station. 23 illustrations. 3,000 words.—*Zeitschrift des Vereines Deutscher Ingenieure,* June 26.

Recent Investigations and Measurements by Pitot Tubes in Propeller Stream Lines.—Experiments are described, made in the small tank of the German Polytechnicum, Charlottenburg, for finding the speed and pressure variations over the disk area of a ship's propeller. The apparatus is described as a Pitot tube with gage adjustable in three directions for covering the full disk at variable axial positions and mounted upon the carriage of the tank. The experiments were conducted so far only upon a propeller driven by an electric motor upon the stationary carriage in one position 3 inches aft of the propeller and in three positions directly in front of the propeller at progressively increasing number of revolutions. The conclusion the author comes to is that there is a forward movement of water aft of the disk of the boss, while aft the major part of the blades it shows the water passing aft except at the tip of the blades, where again a forward movement is recorded attributed to eddy influences. The movement of the stream lines forward of the propeller are all toward it and over a disk area of more than one and a half times the diameter of the propeller distinctly perceptible velocities are recorded. The author gives this series only as preliminary, the war interrupting the experiments by calling away the man in charge and turning the tank room into a hospital. 18 illustrations. 2,100 words.—*Schiffbau,* July 28.

Naval Scouts.—By Commander Ralph Earle, U. S. N. Taking the ground that battle-cruisers, the ideal scouts, are probably out of the question for the United States on account of their great cost and the folly of building less than a homogeneous division of five, the author makes a strong plea for the building of a sufficient number of light scout cruisers of about 5,200 tons displacement and 28 knots speed to round out a well-balanced navy. 13 illustrations. 10,000 words.—*United States Naval Institute Proceedings,* July-August.

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Shipbuilding and General Marine News

Contracts for New Ships—Marine Terminal Improvements—Recent Launchings—Improved Appliances—Personal Items

The demand for the construction of merchant vessels in American shipyards has increased to such an extent that most of the large shipyards on the Atlantic coast are refusing to accept orders calling for delivery before the end of 1917. During the last week in August one large shipbuilding company refused the opportunity to bid on six large vessels, as they were unable to guarantee deliveries inside of three years or more. The situation is well illustrated by the fact that the Ward Line placed an order for two freight steamships with a shipbuilding company in Seattle in order to secure fairly prompt delivery, and another steamship company placed an order in San Francisco, although the vessels are intended for Atlantic service.

The Delaware River district is at the present time the greatest shipbuilding center in the United States, and, counting warship construction, the volume of tonnage now under construction in that district is surpassed only by that at Glasgow. Excluding warship tonnage, the three great shipbuilding centers in Great Britain—Belfast, Glasgow and Newcastle-on-Tyne—are the only shipbuilding centers in the world that lead the Delaware River district.

Shipbuilding Orders

The Newport News Shipbuilding & Dry Dock Company, Newport News, Va., has received a contract to build two more colliers for the Crowell & Thurlow Steamship Company, Boston, Mass. These ships will be about 9,000 tons deadweight.

The Baltimore Dry Docks & Shipbuilding Company, Baltimore, Md., has received a contract from the Trans-Atlantic Motor Ship Company, Ltd., Christiania, Norway, to build two oil tank vessels to be equipped with Bolinder oil engines. This order is in addition to that reported in our August issue.

Orders for six 12,000-ton steamers have been placed by the Osaka Shosen Kaisha Steamship Company, of Japan, with an iron works in Osaka, Japan. The vessels are to be 425 feet long.

The Merrill-Stevens Company, Jacksonville, Fla., was recently awarded the contract for the construction of the United States lighthouse tender *Palmetto* at a cost of $28,975 (£6,000).

The Commissioner of Purchases and Supplies, City Hall, Cleveland, Ohio, has recently opened bids for the construction of the steel hull of a fireboat.

Shipbuilding Contracts Pending

W. H. McWhinney, Aberdeen, Wash., is organizing a company to build a steam schooner to cost $100,000 (£20,500).

The Pacific-Alaska Navigation Company, H. F. Alexander, president, San Francisco, Cal., announces that his company expects to build or buy two steamers for Alaska service.

The Navy Department, Washington, D. C., will open bids on November 17 for the construction of two 32,000 ton battleships. These will be the largest and most powerful ships ever designed for the American navy. The cost of each, exclusive of armor and armament, is limited to $7,800,000 (£1,600,000).

The Ocean Steamship Company (Savannah Line), Pier 35, North River, New York, has had plans for months to build two ships, each 416 feet long. These vessels are meant primarily for coastwise service, but will be constructed to meet the needs of transatlantic voyages. Contracts will be placed as soon as some shipbuilder and the company can agree on prices and time of delivery.

New Steamship Lines

It has been announced in Madrid, Spain, that a new steamship line between Spain and the United States is to be established.

It is reported, apparently on good authority, that a $5,000,000 (£1,070,000) company has been financed for the organization of a Chinese-American Steamship Company to operate between China and the United States Pacific coast.

A barge line to operate between Lake Charles, La., and Port Arthur, Texas, has been organized by Frank Warren, of the Warren Dredging Company, and will, so it is reported, shortly be placed in operation. Twelve barges and a canal boat are said to have been already purchased.

It is reported that Wm. J. Conners, Buffalo, N. Y., is at the head of a corporation which has been organized to effect a merger of the railroad owned steamship lines operating on the Great Lakes, which must be separated from the railroads by December 1 under the decision of the Interstate Commerce Commission.

Shipyard Improvements

The Baltimore Dry Docks & Shipbuilding Company, Baltimore, Md., will, so it is reported, spend about $200,000 (£43,000) in the further enlargement of its present plant, in addition to the $200,000 (£43,000) which it is already spending for that purpose.

The Collingwood Shipbuilding Company, Collingwood, Ontario, is refitting part of its plant for the manufacture of shells and high explosives.

The Maryland Steel Company, Sparrows Point, Md., is receiving bids for the construction of a one-story machine shop, 180 feet by 425 feet, for the marine department.

Important extensions and improvements, it is said, will be undertaken in the near future by the Spedden Shipbuilding Company, Baltimore, Md.

The Baltimore Dry Docks & Shipbuilding Company, Baltimore, Md., has awarded the contract for the construction of a shop to cost $100,000 (£20,500) to the Chesapeake Iron Works.

The Gould Storage Battery Company, Depew, N. Y., which furnishes many of the electric storage batteries for United States submarines, has recently let a contract for the construction of a two-story addition, 75 feet by 200 feet, to its plant.

William Cramp & Sons Ship & Engine Building Company has placed an order with the Pawling & Harnischfeger Company, Milwaukee, Wis., for nineteen 5-ton wall cranes to be installed at its works.

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It is reported that a new corporation will take over the shipbuilding plant of the Herreshoff Manufacturing Company, at Bristol, R. I., and that the capacity of the plant will be very much enlarged. Paul A. Rainey, New Haven, Conn., is mentioned in connection with the enterprise.

Marine Terminal Projects

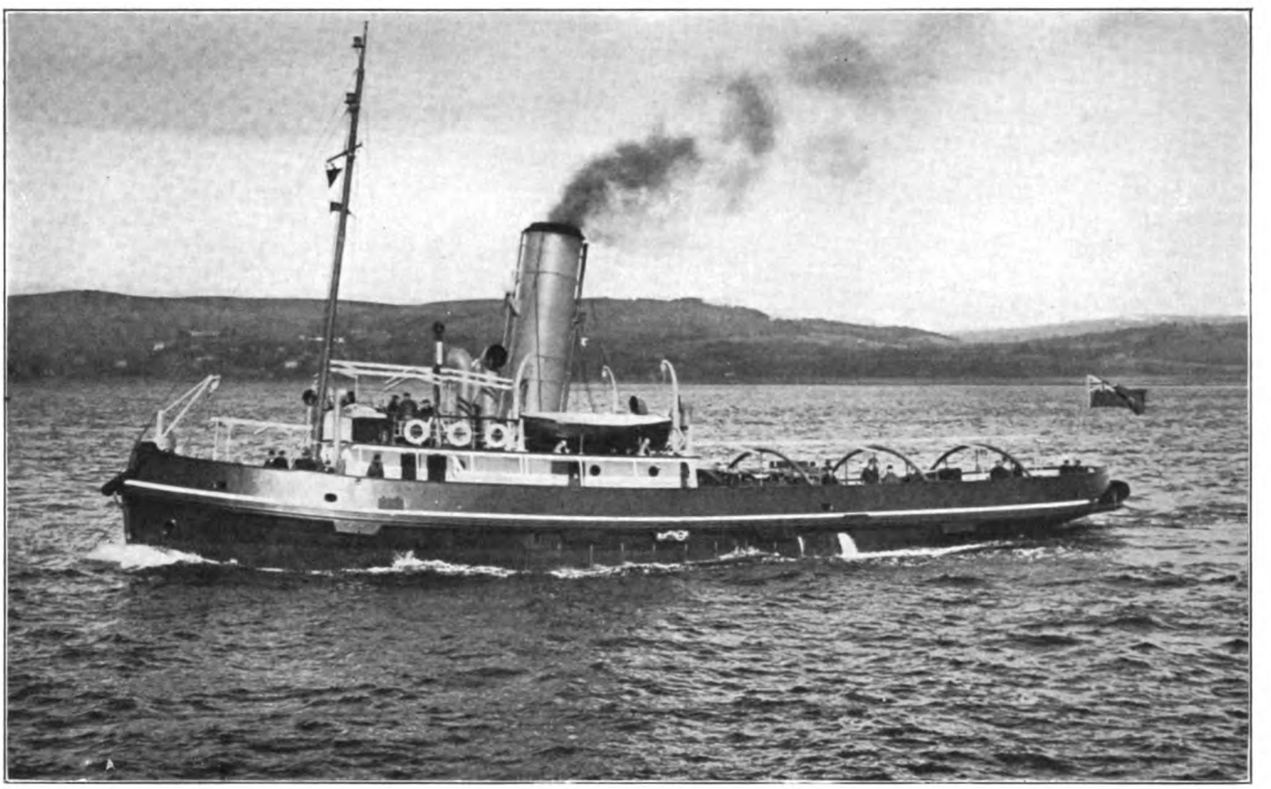
The City of Augusta, Ga., is planning to spend $60,000 (£12,800) in building wharves.

Brown & Watson, Palm Beach, Fla., have received a contract to build a stone pier at Palm Beach.

The city of Pascagoula, Miss., has purchased a site on the Pascagoula River to build wharves and docks. The mayor of the city has the matter in charge.

C. W. Hunt Company, West New Brighton, S. I., has received a contract from the Inter-Island Steam Navigation Company, Honolulu, T. H., for a $1,000,000 (£205,000) coaling plant at Honolulu Harbor.

The Rio Grande Railway Company, Brownsville, Texas, A. Albert Browne, president, has submitted a proposition to the city of Brownsville, to rebuild the wharf at Point Israel and further improve the town's terminal facilities.



Passenger Tender and Tug *J. W. Sauer*. Built by Messrs. Ferguson Brothers, Ltd., for South African Government

The City Commission of Tuscaloosa, Ala., is preparing plans for the construction of a municipal wharf.

The Baldwin Locomotive Works, Philadelphia, Pa., has been granted permission to erect a pier on the Delaware River.

The Board of Port Commissioners, New Orleans, La., is preparing plans for the construction of a wharf to cost about $70,000 (£15,000).

J. A. McEachern, Seattle, Wash., has received a contract to build a pier at Flavel, Ore., for the Great Northern Steamship Company.

S. D. Shinholse, Jacksonville, Fla., has received a contract to construct a dock and warehouse for the Clyde Steamship Company at Sanford, Fla.

The Pennsylvania Railroad Company, Philadelphia, Pa., has let a contract to the Snare & Triest Company, New York, to build a pier at Greenville, N. J.

The State of Texas has approved the $325,000 (£69,600) bond issue recently voted by the City of Orange. About $150,000 (£32,000) of this money is to be spent on wharves and docks.

The Baltimore & Ohio Railroad Company, Baltimore, Md., Daniel Willard, president, is planning the construction of a $1,000,000 (£205,000) coal pier at Curtis Bay, Baltimore.

The Department of Public Utilities, city of St. Louis, Mo., S. W. Bowen, designing engineer, is contemplating the construction of a number of docks to be equipped with up-to-date freight-handling machinery.

Irwin & Leighton, 126 North Twelfth street, Philadelphia, have received a contract from the Ocean Steamship Company, New York, to construct pier sheds at Savannah, Ga. J. G. Basinger, 52 Broadway, New York, is the engineer.

The Engineer of Docks for the Panama Canal is preparing estimates of the cost of constructing an additional 1,000-foot pier at Cristobal, and is also preparing estimates on the cost of replacing timber pier No. 11 with reinforced concrete construction.

The Terminal Transfer & Storage Company, of Mobile, Ala., will shortly begin construction on thirty-two acres of water front land at Mobile of an extensive marine terminal development.

The Gulf, Florida & Alabama Railway Company is building an additional pier at Pensacola, Fla., for the handling of coal. The loading machinery is being constructed by the Link Belt Company, of Chicago and Philadelphia.

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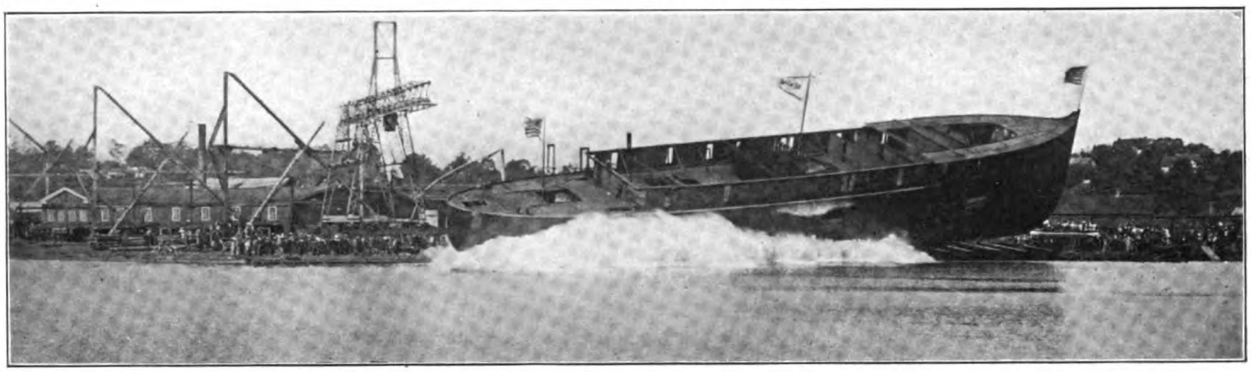


Launch of the *Nevada* at the Yards of the Manitowoc Shipbuilding & Dry Dock Company

Twin Screw Passenger Tender and Tug for South Africa

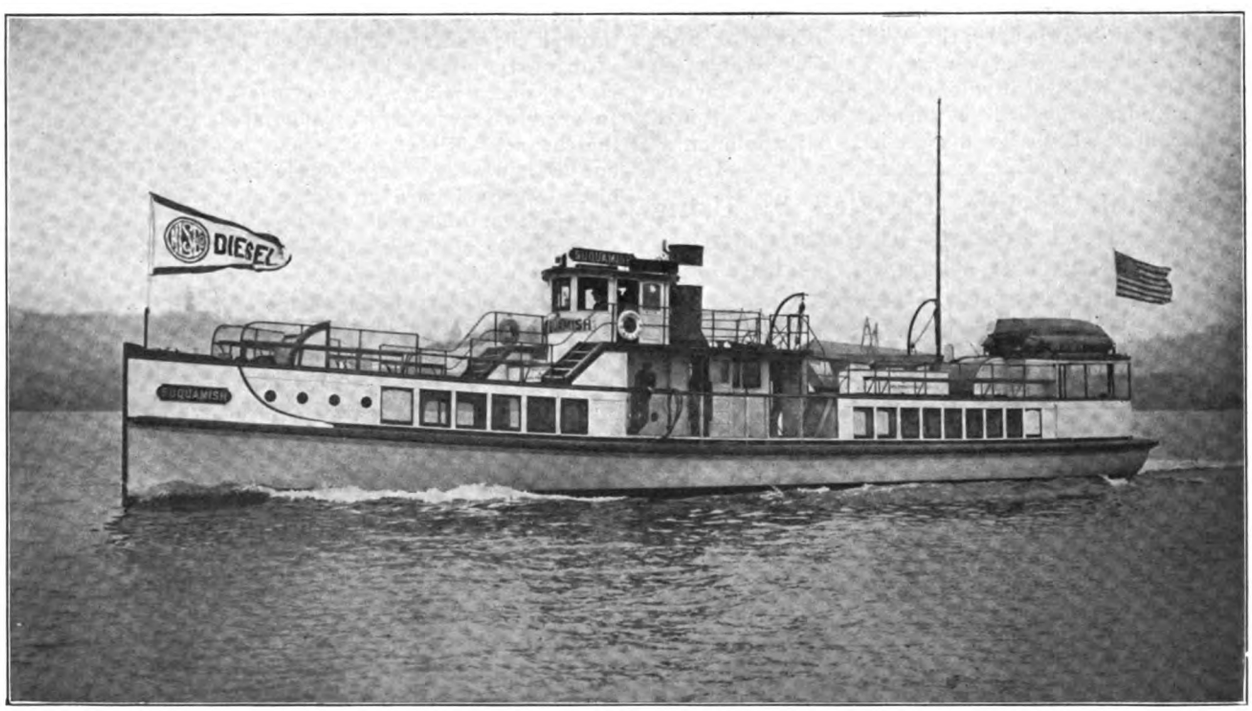
The twin screw passenger tender and tug *J. W. Sauer* illustrated on page 468 is the third vessel of this class which Messrs. Ferguson Brothers (Port Glasgow), Ltd., have built and engined for the Table Bay Harbor Department for the Union of South African Government. The propelling power consists of two sets of triple expansion surface condensing engines with bronze propellers for which steam is supplied by two large multitubular boilers. The vessel is capable of a speed of 12½ knots, which is in advance of the contract speed. In order to provide the vessel with a large radius of action, the coal bunkers have a capacity of 100 tons, and there are a double bottom and deep tanks for boiler feed water, culinary water and fresh water for supplying water to shipping. The machinery auxiliaries comprise a powerful steam winch aft for warping purposes, steam and hand steering gear on the bridge deck, target towing machine, electric engine and dynamo, two centrifugal circulating pumps, separate feed pumps, fire and salvage pumps, separate general service pumps, fan and engine with trunk to stokehold, ash ejector and pump.

Passenger Motor Ship Suquamish

The first Diesel-engined passenger boat in America is the *Suquamish,* owned by the Kitsap County Transportation Company, Seattle, Wash., and operated between Seattle, Wash., and Paulsbo, Wash. The vessel is 92 feet long, 16 feet beam and on a 5-foot draft carries 180 passengers.

Propulsion is by a 180-horsepower Nlseco four-cycle, six-cylinder, vertical single-acting Diesel engine, built by the New London Ship & Engine Building Company, Groton, Conn., which runs at 350 revolutions per minute, giving the vessel a speed of 14 miles per hour. The cost for fuel and lubricating oil averages only 24 cents (1/0) per hour. A supply of fuel oil for two weeks is carried, although there is space for a month's supply. Only one man is required for handling the engine, although on account of the fact that the vessel is in operation from 6 A. M. to 8 P. M., two engineers are required to stand alternate watches.

Owing to the fact that the three round trips which the vessel makes daily include 42 landings, there is a splendid opportunity to test the endurance of the boat, as the clutch and reverse gears are constantly in use at these



The First Diesel-Engined Passenger Boat Built in America. Propulsion is by a 180 Horsepower Nlseco Engine

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landings and the vessel is worked many times under the strain of the "spring line" tied to the wharves. The owners of the *Suquamish* have a number of other vessels of similar size and power engaged in similar trade which, however, are driven by steam, and therefore an opportunity is given for a direct comparison of the two methods. Under these conditions, it is said that the *Suquamish* has given most economical and satisfactory service as compared with the steam-driven vessels.

September Launchings

The United States submarine boat M-1, 185 feet long and 740 tons underwater displacement, was launched by the Fore River Shipbuilding Corporation, Quincy, Mass., on September 14.

The cargo steamer *Annette Rolph*, 9,000 tons deadweight, was launched at the Union Iron Works, San Francisco, Cal., on September 4, seventy-three days after the keel was laid. Her sister ship, the *Eurana*, was launched September 11.

The new steel steamer *Nevada* (described in our August issue), which is being built by the Manitowoc Shipbuilding & Dry Dock Company, Manitowoc, Wis., for the Goodrich Transportation Company, was launched on September 15.

The oil tanker *Silver Shell*, the first of three sister ships building at the yards of the Harlan & Hollingsworth Corporation, Wilmington, Del., for a subsidiary of the Anglo-Petroleum Company, of London, was launched on September 4. The vessel is 435 feet long.

The collier *Plymouth*, 335 feet long, 55 feet beam, 34 feet 6 inches load draft, designed and built by the New York Shipbuilding Company, Camden, N. J., for the Coastwise Transportation Company, Boston, Mass., was launched September 10. The *Plymouth* is a duplicate of the steamer *Franklin* recently completed. She is propelled by engines of 2,000 horsepower designed to give an average speed of 11 knots.

The steam yacht *Whirlwind*, 177 feet long over all, 23 feet 6 inches beam and 7 feet 9 inches draft, designed by Messrs. Cox & Stevens, New York, for Mr. Harry Payne Whitney, was launched by the William Cramp & Sons Ship & Engine Building Company, Philadelphia, Pa., on September 9. The yacht will be propelled by two Parsons geared turbines supplied with steam from an oil-fired tubular boiler. The designed speed is 21 miles an hour.

Remarkable Savings Effected by Using the Oxweld Process in Repair and Reclamation Work of Varied Character on Ore Vessels

The Oxweld Acetylene Company of Chicago, Ill., and Newark, N. J., has recently completed contracts in connection with the winter repair work covering welding and cutting on thirteen ore vessels on the Great Lakes. The work executed was in many cases of unique character in particular field and in all cases resulted in a considerable saving in actual cost, not to mention an enormous saving of time, compared with the usual methods of repair or replacement.

Perhaps the most successful application of Oxweld to hull repairs was to cast iron mooring line chocks, while-lass room chocks and towing chocks. These so badly worn away by wire lines as to be scheduled for renewal were built up and filled in. In cases where the lip above the sheave was broken off entirely a new casting was made and welded on, giving the chocks a new appearance and its original strength. Badly worn chocks were repaired by the Oxweld process at a cost ranging from $8 (£1 13s 4d) to $30 (£6 5s 0d), where renewals would have meant a cost of $100 (£20 16s 8d) to $150 (£31 5s 0d). Chocks were welded in place in from two to seven hours.

Scuppers, which require such precise pattern making in renewing as to make the cost of material a comparatively small item, were welded with absolute success, eliminating the time and expense of making and fitting new patterns. Cracks varying in length from one to four feet were welded at a total cost varying from $10 (£2 1s 8d) to $20 (£4 3s 4d). The time required to remove, weld and reset the scupper was about two days.

As a time saver in cutting steel plates, structural steel, brass, etc., remarkable claims are made for the Oxweld process. Old bulkheads battered and torn were trimmed or cut away with great speed. Steel plates a half-inch thick were cut at the rate of one foot per minute. There was literally miles of cutting done on these vessels. Wale-strakes were cut off, bulkheads trimmed, dead lights cut, brackets, channel flanges, stringers, web frames and bilge plates were all cut out or trimmed.

On one vessel Oxweld apparatus was used to cut off some ten feet of spar. While the cost of cutting per lineal foot is only about one-half the cost involved in drilling and chipping, the enormous amount of time saved with the Oxweld process proves its superiority. With the cutting blowpipe beams and plates were cut down in minutes where the old method would have taken hours.

Cracks in some ⅝-inch steel plate tank tops were Oxwelded at an average cost of from 40 to 50 cents (£0 1s 8d–£0 2s 1d) per inch. A riveted patch for a crack 5 inches long would have cost $30 (£6 5s 0d) at least, while it is claimed the same crack could be Oxwelled for $2.50 (£0 10s 5d).

The intermediate stringer channel flanges, which become so battered and bent by the unloading machines, were heated by the Oxwelding blowpipe in an incredibly short time and straightened by means of alligator jaws operated by two men. When completed the channel has a new appearance and is protected from further wear of this kind by the insertion of a 3-inch oak filler in the wake of the hatches. These fillers are held in place by bolts through the web of the channel. The bolt holes, ⅞ inch in diameter, are cut by the Oxweld cutting flame at the rate of one a minute, costing about 5 cents (£0 1s 0d) each. In many cases the entire flange and part of the web of the channel had been broken out for a distance of from one to four feet, greatly weakening the stringer. Such places were trimmed up square and a section cut from new material to fit and welded in the gap. No other tools than the Oxweld torches were used in this operation—not a rivet was driven—and when completed the fractured flange was restored to its original strength.

Welding propeller blades, propeller shafts, rudders and shoes, not to mention welding repairs of all kinds on and around boilers, are applications of the Oxweld process of daily occurrence in shipyards. Oxwelding as used in hull repairs, however, is a new departure, but it promises to open up a very large field and effect immense savings in time and money to vessel owners.

GREEK MERCHANT MARINE EXPANSION.—Statistics recently published in Greece show that in the eighteen months ending December 31, 1914, there were 89 steamers of 211,921 gross tons added to the list of ships sailing under the Greek flag. According to Lloyd's Register the number of vessels in the merchant fleet of Greece at the end of 1914 was 441 with a gross tonnage of 1,000,000 approximately.

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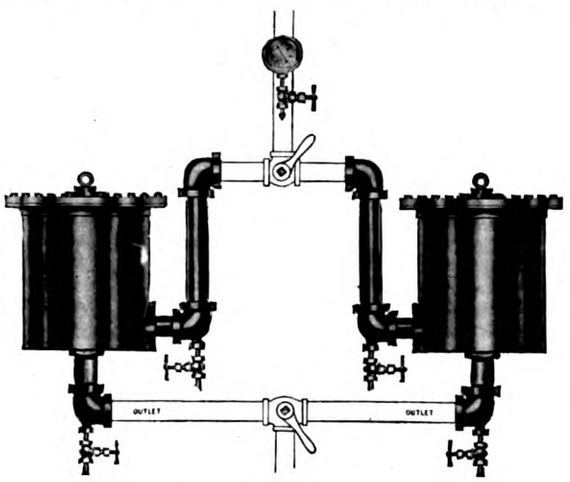
ENGINEERING SPECIALTIES

What Oleite Does

"Deolizer" is the trade name of an instrument for the complete removal of oil from emulsion. It is manufactured and sold by William Andrews, Inc., 120 Liberty street, New York. To de-ole-ize means to de-oil-ize, or take out oil. The material which does this is sold under the trade mark of "Oleite."

Oleite is a discovery, not an invention. The original investigators were endeavoring to perfect a roofing material having certain desirable qualities. In running down the line of experiment they accidentally discovered that at a certain stage of the manufacture the material developed a singular natural affinity for oil, an affinity analogous to that of cement for water. Following up this discovery it was found that Oleite would remove 99.99994 percent of all the oil from an emulsion. So complete was



"Deolizer"

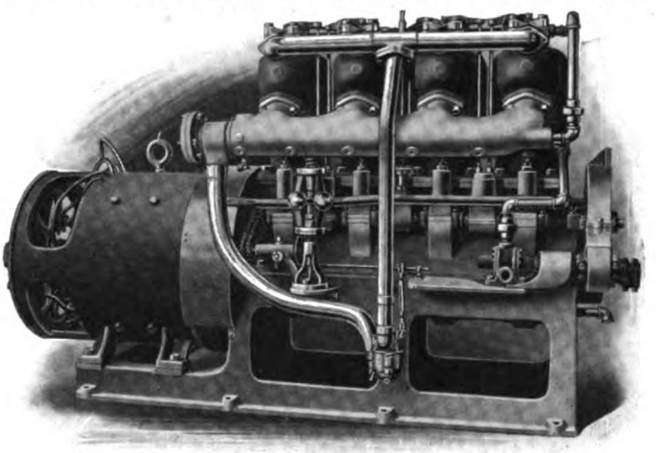
this purification, it is claimed, that it required the delicate ether test to detect the residue, which is equal to about one drop in one and a half barrels of water. The application of Oleite, therefore, in the treatment of condensed returns, whether from heating systems or surface condensers, was at once undertaken and has been followed up with remarkable results.

Although the apparent action of Oleite is that of a filter, its real action in no way resembles the ordinary mechanical straining implied in the term filter. Oleite is a calcined mineral substance granulated to a uniform grade, and in appearance much resembles old-fashioned black gunpowder. The voids are large and if sand or charcoal were used there would be no perceptible effect on the emulsion. Oleite, on the contrary, acts by a remarkable and thus far unexplainable attraction for, and entanglement of, the emulsified particles of oil. It is claimed that it seizes upon every minute atom within reach and, once seized, it never lets go. In time the Oleite is found to coagulate the oil in its voids until the whole mass becomes a sort of jelly. It can be forced to part with the oil only by burning it off. The Oleite itself does not materially suffer by the operation and can therefore be recovered and used a number of times before losing its efficiency.

The action of the Deoleizer is supplementary to the action of the ordinary oil extractor. The latter is set in the flow of the exhaust steam. The former takes the oily returns after condensation and reduces them to a distilled water of limpid clearness and perfect purity in which there is not a measurable trace of oil. This last fractional percent of oil is the elusive one, hard to catch but cumulative in its damage if it gets into the boiler.

Speedway Auxiliary and Emergency Electric Lighting Set

The Gas Engine & Power Company and Chas. L. Seabury & Co., Cons., Morris Heights, New York, has placed on the market a combination auxiliary and generating set such as is now required by law for steam passenger vessels. These generating sets are built in stock sizes of 3, 4, 7, 12 and 25 kilowatts. The larger sets are arranged solely for electric lighting, but the 3 and 4 kilowatt sizes include in addition to the generator a bilge and fire pump and an air compressor. These sets are especially suited to yacht work where the main gasoline (petrol) engines require air for starting purposes. In the smaller sets the engine



12 K. W. Speedway Lighting Set

consists of three vertical cylinders, 4½-inch bore by 5-inch stroke mounted on a cast iron closed frame which in turn is bolted to a body with extension for the generator. The power cylinders are on the ends, while the center cylinder is an air compressor with mechanically operated intake valve. On the end opposite the generator, attached to base plate, is a double-acting bilge pump, 3½-inch bore by 4-inch stroke.

The Pallograph

The only pallograph in America, and, in fact, one of but two or three in existence, has just been completed by the Sperry Gyroscope Company, Brooklyn, N. Y., for use at the Government model basin, Washington, D. C., in connectiton with investigations of the vibration of ships.

Briefly, the pallograph is an instrument which simultaneously records vertical and horizontal transverse vibrations, and while the instrument is primarily intended for use aboard ships, it may be used to trace vibrations or oscillations of any character to their primal source. Its usefulness was strikingly demonstrated several years ago by Dr. Schlick, of Hamburg, Germany, in connection with the trial trip of the Cunard liner *Lusitania,* where excessive vibrations developed at high speeds. Sir William White had been much interested in Dr. Schlick's experiments and it occurred to him that if Dr. Schlick could be persuaded to bring his pallograph to England the trouble might be located.

Accordingly a telegram was dispatched and Dr. Schlick

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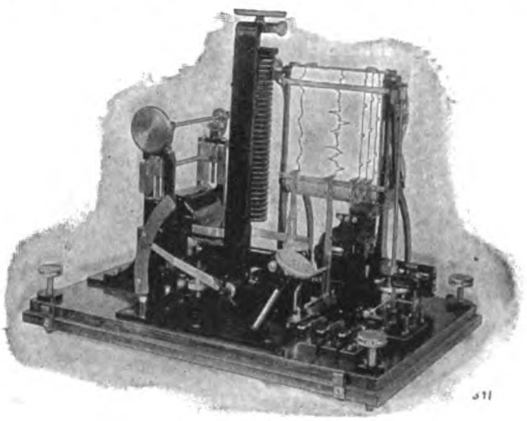
was soon at his task. Working for nearly forty-eight hours, without rest, he finally traced the trouble down to one of the tail shafts; moreover, he reported he was convinced that a blade of the propeller on that particular shaft had not been properly set, and, furthermore, that it was some 2 degrees out of alinement! Such confidence was placed in Dr. Schlick's deductions that the ship was immediately docked, the propeller blades examined and one actually found to be 1.8 degrees offset. Little time was lost in adjustment and the *Lusitania* resumed her interrupted trip—but vibration had been eliminated. Dr. Schlick afterward said that the stern appeared to "jump up and down about a foot," the vibration at other points being not so violent; yet here and there were nodes where



Sperry Pallograph

no tremor was felt—in fact, the great ship behaved as a gigantic violin string.

The Sperry pallograph embodies a number of substantial improvements over the Schlick device, possibly the most important being mechanism which so regulates its period that it will not come into synchronism with any harmonic of the ship's motion. Of equal importance is the introduction of pencils for (1) indicating revolutions of the ship's shafts and (2) a time marker indicating seconds. Records are made on a 5-inch paper strip, moved upwardly at constant speed by a small motor; the speed of travel may be regulated from 1½ inches down to ⅝ inch per second, as required. It will be readily understood that vibrations of high frequency or of considerable amplitude should be recorded on a rapidly moving strip so that the wavy lines of the diagram will be widely separated for thorough analysis—indeed, it is even frequently necessary to enlarge certain sections so that conclusions as to the causes of the vibrations may be determined with absolute certainty.

When the pallograph is in operation the "pendulum" appears to oscillate and vibrate rapidly, whereas in reality it is standing absolutely still and the pallograph structure is moving in unison with the body on which it rests.

The general dimensions of the apparatus are 24 inches long, 14 inches wide and 20 inches high; the weight is approximately 90 pounds.

AMERICAN CITIZENS COMMAND THE MAJORITY OF FOREIGN BUILT SHIPS ADMITTED TO AMERICAN REGISTRY.—Two-thirds of the officers of the foreign built ships admitted to American Registry under the act of August 18, 1914, are American citizens or are men who have taken out their first naturalization papers in the past and will become citizens of the United States after a lapse of varying periods.

PERSONAL MENTION

Operating Engineers

Leo Tillman has been appointed chief engineer of the steamship *California.*

W. G. Oyler is chief engineer of the Border Line steamship *Fulton,* now on the Pacific coast.

George H. Parry has been appointed chief engineer of the tug *E. H. Willard,* of New Orleans, La.

Albert Clark, of New Orleans, La., has been appointed second assistant engineer of the Texas Company's steamer *Louisiana.*

E. H. Milde has been appointed second assistant engineer of the Southern Pacific steamer *Chalmette* at New Orleans, La.

Peter Dietz has been appointed chief engineer of the tug *Robert N. Day,* which is employed on construction work at Albany, N. Y.

A. Boyd, R. Powers and J. Hillary are assistant engineers on the steamship *William O'Brien,* of the Carpenter-O'Brien Company, New York.

Joseph Blunk has been appointed chief engineer of the tug *A. H. Whiteman,* of New Orleans, La., with Raymond Saunders as assistant engineer.

Charles Delacroix, of New Orleans, La., has been appointed chief engineer of the steamer *Natchez.* Hubert Fielder is first assistant engineer.

J. H. Howe, of Cincinnati, Ohio, formerly chief engineer of the *Island Queen,* has been appointed chief engineer of the towboat *Barrett* at Cairo, Ill.

R. J. Welch is chief engineer of the Cuba Distilling Company's steamship *Currier,* which is undergoing repairs at Shewan's yard in Brooklyn, N. Y.

S. F. Alexander is acting chief engineer of the Southern Pacific steamship *El Occidente* during the absence of S. T. Alexander, who is chief engineer of this vessel.

T. E. Dickow has been appointed chief engineer of the large excursion steamer *Island Queen,* of Cincinnati, Ohio, with Clarence J. Scales as first assistant engineer.

C. A. Anderson is acting chief engineer of the Southern Pacific steamship *Antilles* during the absence on account of illness of Gus Atkins, chief engineer of the vessel.

A Berg, formerly chief engineer of the Pacific Coast steamship *Tampico,* has been appointed chief engineer of the *Montara* of the same company, vice George C. Brodersen, resigned.

Melvin Leap has been appointed chief engineer of the *Val T. Collins,* of the Island Creek Coal Supply Company, Huntington, W. Va. Phil Klipp is first assistant engineer of this vessel.

Joseph Stanton, of Athens, N. Y., has been appointed first assistant engineer of the tug *George E. Lattimer,* which is stationed on the New York State Barge Canal at Rexford Flats.

Charles Bortle, formerly chief engineer of the steamer *Julia Safford,* of the Albany & Troy Line, Albany, N. Y., has accepted a position with the Great Lakes Dredge & Dock Company.

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Earl Bryan has been appointed chief engineer of the passenger and freight steamer *Ohio,* running between Cincinnati, Ohio, and Memphis, Tenn., with William H. Weber as first assistant engineer.

Frank B. Davis, for many years first assistant engineer of the steamer *Olivette,* of the Peninsula & Occidental Steamship Company, has been appointed an assistant boiler inspector in the United States Steamboat Inspection Service at New Orleans, La.

James Andus, formerly chief engineer of the steamer *St. Johns,* of the Colonial Beach Company, Washington, D. C., has been transferred to the steamer *Gratitude,* recently purchased to take the place of the steamer *Wakefield* on the Potomac River route.

Joseph Nash has been appointed chief engineer of the steamer *Volunteer,* of the Potomac & Chesapeake Steamboat Company, Washington, D. C. The *Volunteer* was partially destroyed by fire a few weeks ago, and as soon as repairs are completed she will be sent to the James River to run between the Dupont Powder Works plant and Petersburg.

Changes in Steamboat Inspection Service

W. K. Martin has been appointed assistant inspector of the United States Steamboat Service, New York.

Robert Clark has been appointed assistant inspector of the United States Steamboat Inspection Service, Boston, Mass.

Harry Lord has been appoined inspector of boilers of the United States Steamboat Inspection Service at Seattle, Wash.

Whitmore Hill has been appointed local inspector of boilers of the United States Steamboat Inspection Service at Galveston, Texas.

W. I. Gilman has been appointed local inspector of the United States Steamboat Service at Boston, Mass., succeeding Andrew J. Savage, resigned.

Silas H. Hunter has been appointed local inspector of boilers in the United States Steamboat Inspection Service at Cleveland, Ohio., vice James McGrath, resigned.

Philip J. Shaw has been appointed local inspector of boilers of the United States Steamboat Inspection Service at Providence, R. I., succeeding Charles A. Potter, deceased.

Harvey S. Haynes, local inspector of boilers at Evansville, Ind., and formerly chief engineer of the Corrigan fleet, has been appointed assistant local inspector of boilers in the United States Steamboat Inspection Service, at Cleveland, Ohio.

Naval Architects, Consulting Engineers, Draftsmen and Shipyard and Steamship Officials

F. K. Ruprecht, formerly a draftsman in the hull division of the New York Navy Yard, is with John A. MacAdam & Company, New York City.

William Binley, Jr., formerly chief draftsman at the New York Navy Yard, is now chief draftsman and assistant to the general manager at the Fore River Shipbuilding Corporation, Quincy, Mass.

Walter A. Read, formerly assistant chief draftsman at the New York Navy Yard, is president of the Read Collecting Agency, Boston, Mass., taking the place left vacant by the sudden death of his father.

R. Earle Anderson, formerly general manager of the Augusta-Savannah Navigation Company, Augusta, Ga., has been appointed assistant general superintendent of the Winchester Repeating Arms Company, New Haven, Conn.

Arthur Fuller, formerly Pacific coast sales agent of the New London Ship & Engine Company, Groton, Conn., has been appointed general sales agent of that concern, with headquarters at Groton, Conn.

Naval Advisory Board

The Secretary of the United States Navy announced on September 12 the names of the twenty-three engineers and scientists who will constitute the Advisory Board to assist the navy in its technical problems of development. Eleven of the leading scientific societies in the country were requested to nominate two members each to serve on the Board, and these nominations were approved by the Secretary of the Navy. The first meeting of the Board will be held in Washington on October 6. The following is the *personnel* of the Board:

Thomas A. Edison, Chairman.

American Society of Mechanical Engineers—Robert Le Roy Emmet, consulting engineer, General Electric Company, Schenectady, N. Y.; Spencer Miller, chief engineer, Lidgerwood Manufacturing Company, New York.

American Institute of Electrical Engineers—Frank A. Sprague, consulting engineer, New York; B. G. Lamme, chief engineer, Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa.

American Society of Civil Engineers—Andrew Murray Hunt, consulting engineer, San Francisco and New York; Alfred Craven, chief engineer, Public Service Commission, first district, New York.

American Electrochemical Society—Joseph W. Richards, Professor of Electro Chemistry, Lehigh University, South Bethlehem, Pa.; Lawrence Addicks, consulting engineer, Douglas, Ariz.

American Chemical Society—W. R. Whitney, Director of Research Laboratory, General Electric Company, Schenectady, N. Y.; L. H. Baekeland, Yonkers, N. Y.

American Institute of Mining Engineers—William Lawrence Saunders, Chairman, Board of Directors, Ingersoll-Rand Company, New York; Benjamin Bowditch Thayer, president, Anaconda Copper Mining Company, New York.

The Inventors' Guild—Peter Cooper Hewitt, consulting engineer, New York; Thomas Robbins, president, Robbins Conveying Belt Company, Stamford, Conn.

American Mathematical Society—Robert Simpson Woodward, president, Carnegie Institute, Washington, D. C.; Arthur Gorden Webster, Professor of Physics, Clark University, Worcester, Mass.

American Society of Automobile Engineers—Andrew L. Riker, vice-president, Locomobile Company, Detroit, Mich.; Howard E. Coffin, vice-president, Hudson Motor Car Company, Detroit, Mich.

American Society of Aeronautic Engineers—Henry Alexander Wise Wood, engineer and manufacturer of printing machinery, New York; Elmer Ambrose Sperry, president, Sperry Gyroscope Company, Brooklyn, N. Y.

American Aeronautical Society—Matthew Bacon Sellers, Director of Technical Board of the Aeronautical Society of America, Baltimore, Md.; Hudson Maxim, ordnance and explosive expert, Brooklyn, N. Y.

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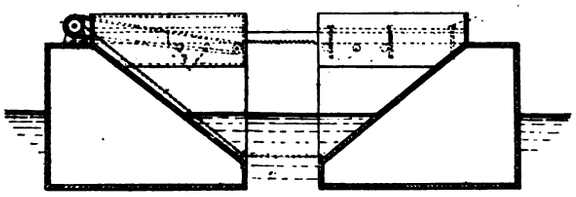
SELECTED MARINE PATENTS

The publication in this column of a patent specification does not necessarily imply editorial commendation.

American patents compiled by Derbert H. Decker, Esq., registered patent attorney, Millerton, N. Y.

1,138,468. SELF-DUMPING SCOW. FRANKLIN PIERCE EASTMAN, OF NEW YORK, N. Y.

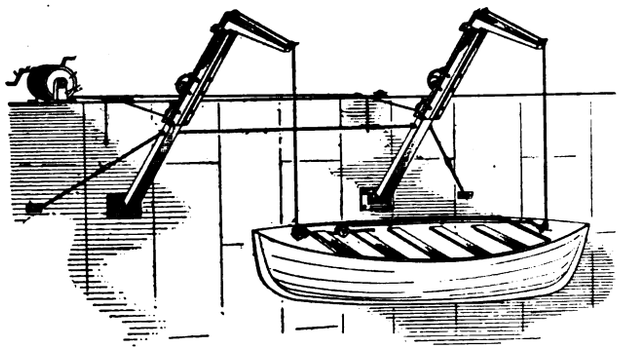
Claim 1.—A self-dumping scow, comprising two hulls affording between them a hopper for holding the load at the time the hulls are abutting sidewise and for allowing the load to dump automatically on



the hulls moving apart, and connecting means at a right angle to the length of the scow and slidably connecting the hulls with each other to maintain the hulls in the same plane when closed or open. Ten claims.

1,140,046. DEVICE FOR LAUNCHING LIFEBOATS. ROBERT WILLIAM LEEMING, OF BRANTFORD, CANADA.

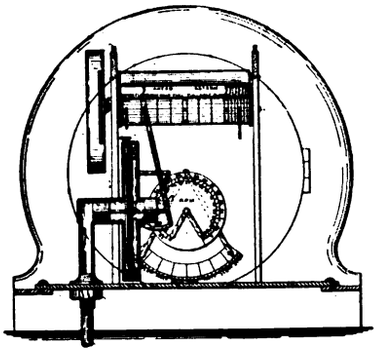
Claim 1.—A pair of davits, each of the said davits comprising a column or upright of channel shape, an arm rotatably connected with the upper end of the column or upright to revolve around the upright, a bracket adapted to be secured to a fixed support at each davit, a hinge connection between each column and the adjacent bracket for permitting the upper end of the column to swing outwardly and downwardly, said column



being adapted to extend above the boat deck of a vessel, a pulley journaled at the outer end of each arm, a pulley journaled on the arm near the top of each column, a pulley journaled on each column intermediate the ends thereof, a flexible member passing over the pulleys and having a davit hook at its outer end for engaging a boat to support the same, and brake mechanism in connection with each column for preventing movement of the flexible member, said mechanism being arranged on the column between the last-named pulleys and comprising a pair of blocks having registering grooves for receiving the flexible member, the blocks being connected with respect to each other, and means for clamping the outer block on the inner block. Twelve claims.

1,145,884. SHIP'S INDICATOR, EDWIN A. FISH, OF NEW LONDON, CONN., ASSIGNOR BY MESNE ASSIGNMENTS, TO FISH AUTOMATIC SHIP'S LOG COMPANY, A CORPORATION OF NEW YORK.

Claim 1.—A ship's log and recorder including a platen roll, means for feeding paper over said roll with a predetermined movement, a

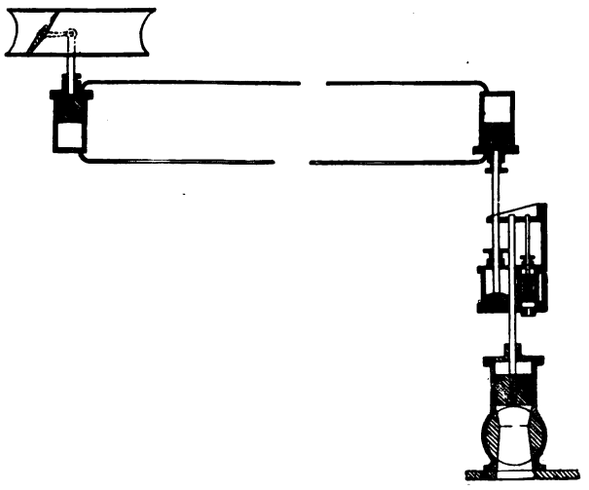


stylus, a flexible member, a cylinder, and a steam actuated piston therein connected with said flexible member for flexing the same, and connections between said flexible member and stylus embodying an arm and connections whereby said stylus is caused to traverse the paper with a movement parallel with the axial center of the platen roll. Six claims.

British patents compiled by G. F. Redfern & Company, chartered patent agents and engineers, 15 South street, Finsbury, E. C., and 10 Gray's Inn Place, W. C., London.

12,736/1914. APPARATUS FOR PREVENTING RACING OF MARINE PROPELLERS. G. SHOTTON, 44 WESTBOURNE ROAD, PENARTH, GLAMORGAN.

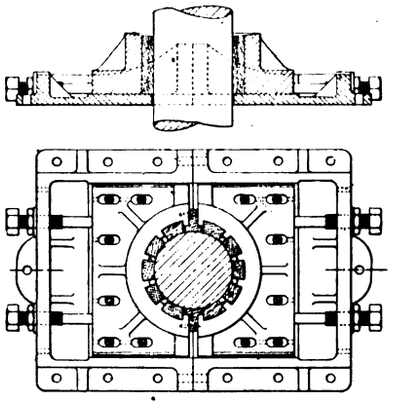
Claim.—An apparatus for preventing racing of marine propellers, consisting of a piston in a vertical cylinder open at its lower end to the water, the movements of which control the throttle valve of the propelling engine, and the displacements of which piston displace a lever



connected to a valve controlling the admission of fluid pressure to a motor cylinder having a piston connected to the throttle valve, the consequent displacements of the fluid-pressure-actuated piston returning the valve, by means of a lever of fixed fulcrum connected to the fluid-pressure-actuated piston rod and to the valve lever, in which the valve lever is pivoted on the lever of fixed fulcrum at an intermediate portion of its length.

13,053/14. STUFFING BOXES FOR RUDDER POSTS. W. C. J. COPEMAN, FURNESS HOUSE, BILLITER STREET, LONDON, E. C.

This invention has for its object to provide a stuffing box which shall be simple in construction, shall be easily adjusted to take up wear in the bearings of the stuffing box and shall, if desired, be self-lubricating. It comprises two adjustable cheeks, each of which is provided with a



semi-circular opening or recess to receive the rudder post, the said openings being provided with blocks of wood, say lignum vitæ, between which graphite or other lubricating material is placed, a base-plate is provided having a suitable opening therein to receive the rudder post. The two cheeks, each having the semi-circular opening, are arranged on the base-plate so as to be capable of adjustment and the cheeks may be firmly secured to the base-plate by means of bolts.

27,571/1913. IMPROVEMENTS IN OR RELATING TO FIRE EXTINGUISHING AND ALARM APPARATUS FOR USE ON BOARD SHIPS. F. W. SMITH, 5 THORNBURN AVENUE, AND H. S. WARREN, 70 MILLBROOK ROAD, SOUTHAMPTON.

In a fire extinguishing and alarm apparatus of the type in which one or more water pipes extend to compartments in a ship in which fusible plugs are employed to close water apertures either directly or through the agency of valves and in which means are provided in the branch pipes leading to each compartment, said means being operable by the flow of water in the branch pipes to give an indication at a suitable station of the particular apartment affected, the provision in connection with each compartment of a rotary water motor placed in each branch between the compartment and the main pipe, so that if a plug melts, the flow in the corresponding branch pipe operates the water motor which closes an electric circuit intermittently, and so causes to be given at a suitable station an alarm which appertains to the particular apartment affected.

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